EPA/ROD/R10-00/046
2000

EPA Superfund
Record of Decision:

BANGOR NAVAL SUBMARINE BASE
EPA ID: WA5170027291
OU 08
SILVERDALE, WA
09/27/2000

Final

RECORD OF DECISION
Naval Submarine Base Bangor
Operable Unit 8
Kitsap County, Washington

September 2000

EPA
United States
Environmental Protection
Agency

WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

Naval Submarine Base Bangor

DECLARATION

Site Name and Location

Naval Submarine Base, Bangor
Operable Unit 8
Silverdale, Washington
CERCLIS ID: WA5170027291

Statement of Basis and Purpose

This decision document presents the Selected Remedy for Operable Unit 8 (OU 8) at the Naval Submarine Base (SUBASE) Bangor, in Silverdale, Washington. The selected remedy was chosen in accordance with the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980, as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986, and, to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). This decision is based on the Administrative Record file for OU 8. OU 8 consists of contaminated groundwater on base that has migrated off base and residual contaminated soil from a depth of 15 feet below ground surface (bgs) to the water table. The residual contaminated soils are located on the base.

The United States Department of the Navy (Navy) is the lead agency for OU 8. The United States Environmental Protection Agency (EPA) and the Washington State Department of Ecology (Ecology) have participated in the site investigations and in evaluating alternatives for remedial action. Ecology and EPA concur with the selected remedy.

Assessment of the Site

The response action selected in this Record of Decision (ROD) is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment. Such a release, or threat of release, may present an imminent and substantial endangerment to public health, welfare or the environment.

Description of the Selected Remedy

OU 8 addresses contaminated groundwater on base that has migrated from the Public Works Industrial Area (PWIA) to an off-base residential area known as Mountain View. The major components of the selected remedy for OU 8 include the following:

- Monitor groundwater geochemical characteristics to confirm destruction of contaminants through natural attenuation and biodegradation is occurring at a rate sufficient to meet remedial goals, and that conditions favorable to the destruction of chemicals of concern through biodegradation and natural attenuation continue throughout site-wide groundwater.

- Installation of a free-product recovery system to remove light non-aqueous phase liquid (LNAPL) that is floating on the surface of the water table beneath the PWIA. The LNAPL resulted from gasoline that had leaked from an underground (UST) storage tank, as well as from periodically overfilling the UST since it became operational in the mid 1940s.

- Continued management of institutional controls in the form of groundwater use restrictions, prohibition on new well installations, and the provision of an alternate water supply to Mountain View residents.

The LNAPL beneath the PWIA is the "Principal Threat Material" at OU 8 as defined by NCP Section 300.430. In 1986, the Navy installed a free product extraction system, which consisted of three extraction wells. The system was shut down in 1998 when free product was no longer detected in the extraction wells. However, LNAPL was still detected in several monitoring wells located in the PWIA. Under the selected remedy, a free-product recovery system will be installed to recover the remaining LNAPL beneath the PWIA to the extent practicable.

The low-level threat waste at OU 8 is petroleum-contaminated soil in an eight-foot thick zone beneath the PWIA from depth of 15 bgs to the water table. The soil contamination is limited to the vicinity of the gasoline service station in the PWIA. Because the water table is presently at a historically high level (approximately 22 feet bgs), most of the contaminated soil is below the water table. There are no human health risks related to exposure to subsurface soil. Human health risks associated with OU 8 are related to ingestion of constituents in the groundwater, and a source of those constituents is the LNAPL on the water table and the residuals in soil that lie at depths greater than 15 ft bgs. The LNAPL found at the site presents a significant ongoing groundwater contamination source, while contributing to the residual soil contamination. A soil removal action to address contamination at these depths within the confines of a heavily developed PWIA would be extremely difficult, costly, and would not significantly minimize further groundwater contamination. Natural attenuation and biodegradation may be applicable for the soil once the LNAPL has been removed to the extent practicable from the site. However, the remedy will remain in place until groundwater meets cleanup goals, at which time the residual soil contamination will no longer represent a source or pose a threat to groundwater quality. Accordingly, the residual contaminants in soil from a depth of 15 feet bgs to the water table do not need to be actively addressed in this remedy. The status of the groundwater cleanup goals and residual soil contaminants will be evaluated within the 5-year review process.

The volatile organic compound (VOC) contamination in OU 8 groundwater will be addressed by monitored natural attenuation and other actions that may be implemented as part of the contingency remedy provisions in this ROD. Institutional controls will be used to ensure that no human exposure or use of contaminated or potentially contaminated groundwater occurs.

Statutory Determinations

The Selected Remedy is protective of human health and the environment, complies with Federal and State requirements that are legally applicable or relevant and appropriate to the remedial action, and is cost-effective. The remedy utilizes permanent solutions and alternative treatment

technologies that permanently and significantly reduce the toxicity, mobility, or volume of hazardous substances, pollutants, or contaminants through treatment.

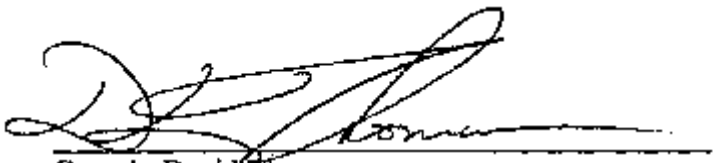
Because the selected remedy will result in hazardous substances, pollutants, or contaminants remaining on-site above levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted within five years after initiation of remedial action to ensure that the remedy continues to provide adequate protection to human health and the environment.

ROD Data Certification Checklist

The following information is included in the Decision Summary section of this ROD. Additional information can be found in the Administrative Record for this Site.

- COCs and their respective concentrations (Sections 5-9 and 5-10, Tables 5-4 through 5-8).
- Baseline risk represented by the COCs (Section 7, Tables 5-9 and 5-10).
- Cleanup levels established for COCs and the basis for these levels (Section 8.0, Table 8-1).
- How source materials constituting principal threats will be addressed (Section 9).
- Current and reasonably anticipated future land use assumptions and current and potential future beneficial uses of groundwater used in the baseline risk assessment and ROD (Section 6).
- Potential land and groundwater use that will be available at OU 8 as a result of the Selected Remedy (Section 11.9).
- Estimated capital, annual operation and maintenance (O&M), and total present worth costs, discount rate, and the number of years over which the remedy cost estimates are projected (Section 11.10, Tables 11-1 through 11-6).
- Decisive factor(s) that led to selecting the remedy (Section 11.6).

Signature sheet for the Naval Submarine Base Bangor, Operable Unit 8 Record of Decision between the United States Navy and the United States Environmental Protection Agency, with concurrence by the Washington State Department of Ecology.



Captain David Thomas,
Commanding Officer,
Naval Submarine Base, Bangor
United States Navy

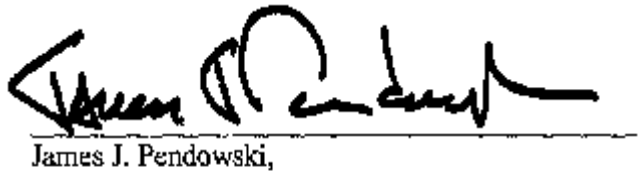
9/24/00
Date

Signature sheet for the Naval Submarine Base Bangor, Operable Unit 8 Record of Decision between the United States Navy and the United States Environmental Protection Agency, with concurrence by the Washington State Department of Ecology.

Charles E. Findley,
Acting Regional Administrator,
U.S. Environmental Protection Agency
Region 10

9-27-00
Date

Signature sheet for the Naval Submarine Base Bangor, Operable Unit 8 Record of Decision Between the United States Navy and the United States Environmental Protection Agency, with concurrence by the Washington State Department of Ecology.



9/27/00

James J. Pendowski,
Program Manager,
Toxics Cleanup Program
Washington Department of Ecology

Date

DECISION SUMMARY

The United States is required to comply with the provisions of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) in the same manner and to the same extent as a non-governmental entity. Pursuant to Executive Order 12580, the Department of the Navy is the lead agency under CERCLA for remedial action at SUBASE Bangor, a facility listed on the National Priorities List (NPL). Remedial action will be implemented pursuant to the Record of Decision (ROD) for Operable Unit 8 to minimize the release or threat of release of hazardous substances associated with groundwater contamination. The remedial action will comply with federal and state applicable or relevant and appropriate requirements (ARARs).

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LIST OF TABLES

(Tables are presented at the end of the Decision Summary.)

LIST OF FIGURES

(Figures are presented at the end of the Decision Summary)

LIST OF ACRONYMS

AE	Average Exposure
ARAR	Applicable or Relevant and Appropriate Requirement
AWQG	Ambient Water Quality Goal
bgs	below ground surface
BTEX	Benzene, Toluene, Ethylbenzene, & Xylenes
CAA	Clean Air Act
CDI	Chronic Daily Intake
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CLARC II	Cleanup Levels and Risk Calculation Update (under MTCA)
COC	Chemical of Concern
COPC	Chemical of Potential Concern
DCA	1,2-Dichloroethane
DCE	1,1-Dichloroethene
EA	EA Engineering, Science, and Technology
Ecology	State of Washington Department of Ecology
EFANW	Engineering Field Activity Northwest
EPA	United States Environmental Protection Agency
ESD	Explanation of Significant Differences
FFA	Federal Facilities Agreement
FPR	Free-Product Recovery
FS	Feasibility Study
ft	foot or feet
gpm	gallons per minute
GPR	Ground Penetrating Radar
GRA	General Response Action
GSA	General Services Administration
HEAST	Health Effects Assessment Summary Tables
HHRA	Human Health Risk Assessment
HI	Hazard Index
HQ	Hazard Quotient
IAS	Initial Assessment Study
IC	Institutional Control
ICMP	Institutional Controls Management Plan
IRIS	Integrated Risk Information System
kg	kilogram
L	liter
LNAPL	Light Non-Aqueous Phase Liquid
LTM	Long Tenn Monitoring
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
mg	milligram
Mn	manganese

LIST OF ACRONYMS (Continued)

MNA	Monitored Natural Attenuation
msl	mean sea level
MTCA	Model Toxics Control Act (WAC 173-340)
Fg	microgram
NACIP	Navy Assessment and Control of Installation Pollutants
Navy	United States Department of the Navy
NPL	National Priorities List
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
O&M	Operation and Maintenance
OU	Operable Unit
P&T	Pump and Treat
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated Riphenyl's
PQL	Practical Quantification Limit
PRG	Preliminary Remediation Goal
PSCAA	Puget Sound Clean Air Agency
PWIA	Public Works Industrial Area
Qva	Vashon Advance Outwash
Qvt	Vashon Till
RAB	Restoration Advisory Board
RACER	Remedial Action Cost Engineering and Requirements
RAG	Risk Assessment Guidance
RAO	Remedial Action Objective
RBC	Risk-Based Concentration
RBSC	Risk-Based Screening Concentration
RCRA	Resource Conservation and Recovery Act
RFD	Reference Dose
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RM	Redox Manipulation
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act of 1986
SDWA	Safe Drinking Water Act
SEPA	State Environmental Policy Act
SF	Carcinogenic Slope Factor
SMCL	Secondary Maximum Contaminant Level
SUBASE	Naval Submarine Base
SVE	Soil Vapor Extraction
SVOC	Semivolatile Organic Compound
SWFPAC	Strategic Weapons Facility, Pacific
TCA	1,1,1-Trichloroethane

LIST OF ACRONYMS (Continued)

TCE	1,1,1-Trichloroethene
TCLP	Toxicity Characteristic Leaching Procedure
TOC	Total Organic Carbon
TPH	Total Petroleum Hydrocarbons
TPH-G	Total Petroleum Hydrocarbon as Gasoline
UST	Underground Storage Tank
VOC	Volatile Organic Compound
WAC	Washington Administrative Code

Responsiveness Summary

1. SITE NAME, LOCATION, AND DESCRIPTION

1.1 SITE NAME AND LOCATION

The Naval Submarine Base (SUBASE) Bangor is located on Hood Canal in Kitsap County, Washington (Figure 1-1). It is approximately 1.5 miles west of the City of Poulsbo. Land surrounding SUBASE Bangor is generally undeveloped or supports limited residential uses.

OU 8 consists of approximately 150 acres of land and is located in the southeastern corner of SUBASE Bangor. It encompasses the Public Works Industrial Area (PWIA) and off-base residential community along Mountain View Road between Clear Creek Road and the SUBASE Bangor boundary (Figure 1-2).

1.2 SITE DESCRIPTION

SUBASE Bangor is approximately 7,200 acres in size and is located in Silverdale, Washington. It was first established in 1944 as the U.S. Naval Magazine Facility to provide a deep-water shipment facility for ordnance. The base became the primary command for ammunition activities in the Puget Sound region by 1948, with a mission of transshipment and supply of fleet ordnance, and demilitarization of unserviceable and dangerous ammunition.

The Polaris Missile Facility was added to ordnance operations in 1963. Ordnance operations and demilitarization activities reached a peak between 1966 and 1970 in support of the Vietnam War. In 1970, ship-loading operations were transferred to the Naval Weapons Station, Concord (California), and Bangor was linked with the Naval Torpedo Station, Keyport. Demilitarization activities continued on a limited basis until 1978.

In the early 1970s, many new building facilities were constructed, and older ones demolished in preparation as a submarine base. SUBASE Bangor has served as a homeport for the TRIDENT Submarine Launched Ballistic Missile System since 1977. The current mission of the base is to provide administrative and personnel support for submarine force operations, and to provide logistical support for other Navy activities.

On 22 July 1987, a portion of SUBASE Bangor (Site A) was added to the United States Environmental Protection Agency's (EPA) National Priorities List (NPL) of hazardous waste sites. On 30 August 1990, the remainder of the SUBASE Bangor facility was listed on the NPL.

On 29 January 1990, the United States Department of the Navy (Navy), EPA, and the Washington State Department of Ecology (Ecology) entered into a Federal Facilities Agreement (FFA) for the study and cleanup of possible contamination on the SUBASE Bangor property. The potentially contaminated sites at SUBASE Bangor were grouped into seven operable units (OUs) based on geographic location, suspected contamination or other factors (Figure 1-1). A separate study was conducted for each OU to determine appropriate cleanup actions. The eighth

operable unit, OU 8, was later added to the FFA in 1994. This Record of Decision (ROD) presents the selected remedy for OU 8.

OU 8 is comprised of the following known or suspected former waste sites:

- Site 27 Steam Cleaning Pit
- Site 28 Paint Shop Drainage Ditch
- Site 29 Public Works Maintenance Garage

Sites 27, 28, and 29 are located within the PWIA and were also studied during remedial investigations of OU 7. As shown on Figure 1-2, Sites 10, 18, and 25 are also located within the PWIA; however, these sites were investigated under different OUs. Sites 10 and 18 were investigated under OU 7, and Site 25 was investigated under OU 3.

OU 8 also encompasses a plume of groundwater contamination that emanates from the PWIA and extends in a southeast direction toward the Mountain View residential neighborhood. There are no known flood plains, endangered species, historical landmarks, or structures with historical significance identified at OU 8.

2. SITE HISTORY AND ENFORCEMENT ACTIVITIES

This section provides background information on:

- past activities that have led to the current contamination,
- environmental investigations conducted under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA), and
- history of CERCLA enforcement activities.

2.1 SITE HISTORY

OU 8 is comprised of Sites 27, 28, 29, and contaminated groundwater that has migrated off base. Sites 27, 28, and 29 are located within the PWIA. The PWIA is, approximately, bounded to the north, east and south by Sculpin Circle, and to the west by Scorpion Avenue. This area has been extensively developed since SUBASE Bangor was commissioned in 1944. Prior to 1973, most of the land surfaces in the PWlA were soil covered, but have since been paved. The off-base portions of OU 8 include agricultural lands and low-density residential areas referred to herein as the Mountain View residential neighborhood.

2.1.1 Site 27 – Steam Cleaning Pit

Site 27 is located between Buildings 1203 and 1014, and is the location of a former stearn cleaning pit (Figure 1-2). The pit consisted of an excavated sump filled with gravel that was used to collect and dispose of stearn cleaning condensate generated from locomotive maintenance in Building 1014. When the pit was full, the grease and residue was hauled away to an unknown location for disposal. Although there are differing accounts as to the exact location and depth of the pit, historical records and interviews with SUBASE Bangor personnel indicate that the pit also may have been used for the disposal of spent solvents, waste oils, and pesticides. The pit was filled and paved over during the construction of the new SUBASE Bangor facilities in the late 1970s.

2.1.2 Site 28 – Paint Shop Drainage Ditch

Site 28 is located at the former paint shop (Building 1032) that was used by public works personnel to mix and apply paint. Building 1032 was supposedly located between existing buildings 1016 and 1204; however, its location is not identified on historical base maps and it may not have existed at all (Figure 1-2). Waste materials from the paint shop were reportedly disposed of in a ditch adjacent to the building, the exact location of which is not known. Building 1032 was demolished (date unknown), and the underlying soils were extensively reworked during the construction and installation of underground tanks/pipes for the gas station at Building 1204.

Spray painting was also performed by Public Works personnel in former Building 17 (also referred to as 10 17), located at the current position of Building 1204 (Figure 1-2). Building 17 is

identified on historical maps of the PWIA (Figure 1-2). Paint wastewater and sludge from Building 17 were reportedly either discarded as common trash, or dumped behind the building until about 1970. Currently, it is unclear as to whether painting and related disposal activities occurred at both former building locations (i.e., 1032 and 17), or just at Building 17. Since Building 1032 does not appear on historical maps, it is assumed that former Building 17 was the location of the paint shop.

2.1.3 Site 29 – Public Works Maintenance Garage

Site 29 is located immediately adjacent to the west and southwest portions of Building 1021 (Figure 1-2). This area was historically used to rinse neutralized pesticide containers near the steam cleaning racks on the west side of Building 1021. In addition, trucks and other vehicles were routinely serviced in this area.

2.1.4 Volatile Organic Compounds (VOCs) Contaminated Groundwater

The groundwater investigation at OU 8 was initiated in February 1994 when the Kitsap County Health District notified the Navy that VOCs were detected in a water supply well located in the Mountain View residential neighborhood. This well (PW01) was a newly installed well located near the western end of Mountain View Road approximately 150 feet south of the base boundary (Figure 1-2). In March 1994, groundwater samples were collected from PW01 and seven other private wells along Mountain View Road. Analytical results indicated low concentrations of VOCs in groundwater from PW01; however, no VOCs were detected in the other active drinking water well samples.

In response to the discovery of VOCs, the Navy organized a team of local, state, and federal health and environmental officials to evaluate the extent of VOC contaminated groundwater, and to determine potential source areas. The Navy has conducted two voluntary time-critical removal actions. In 1995, the Navy connected the Mountain View neighborhood to a municipal water supply to minimize human exposure to contaminated groundwater. And in 1996, the Navy installed a containment system to minimize off-base groundwater plume migration.

2.2 REGULATORY HISTORY

The Navy initiated environmental investigations at SUBASE Bangor in 1980 through the Navy Assessment and Control of Installation Pollutants (NACIP) program. As part of the NACIP program, an Initial Assessment Study (IAS) was conducted at SUBASE Bangor and other naval facilities throughout the Puget Sound region. The purpose of the IAS was to identify and assess environmental contamination resulting from past hazardous materials storage, transfer, processing, and disposal operations. A total of 29 potentially contaminated sites were identified at SUBASE Bangor. The IAS recommended that ten sites be further investigated. None of the ten sites were located within OU 8.

On August 30, 1990, SUBASE Bangor was listed on the EPA's National Priorities List. Previously, in July 1987, a 6-acre hazardous waste site on the base known as Site A was placed

on the NPL under the name "Bangor Ordnance Disposal." That site is included under the basewide listing of 1990. On January 29, 1990, the Navy, EPA, and Ecology entered into a Federal Facilities Agreement. The agreement establishes a procedural framework and schedule for developing, implementing, and monitoring appropriate response actions for SUBASE Bangor in accordance with CERCLA, as amended by the Superfund Amendments and Reauthorization Act (SARA), and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). It also set out the oversight procedures for EPA and Ecology to ensure that the Navy is in compliance with applicable or relevant and appropriate requirements (ARARs). In 1990, the FFA identified seven OUs.

Listing on the NPL and execution of the FFA requires the Navy to perform a remedial investigation/feasibility study (RI/FS) to investigate the seven OUs. OU 8 was added to the FFA on September 15, 1994. During 1995 through 1996, an extensive remedial investigation field program was conducted to characterize conditions at OU 8. The program included sampling and analysis of subsurface soil, soil vapor, sediment, and groundwater.

3. COMMUNITY PARTICIPATION

This section summarizes the community relations activities performed by the Navy during the RI/FS for OU 8 during the period of June 1996 through June 2000, when the public comment period ended on the Proposed Plan for this selected remedy.

A SUBASE Bangor Community Relations Plan for the remedial activity on the base was prepared and is available for review at the information repositories. Community relations activities have established communication among citizens living near OU 8, the Navy, EPA, and Ecology. Actions taken to satisfy the requirements of federal law are listed below.

- Restoration Advisory Board (RAB) was formed in December 1995.
- RAB meetings were held twice a month in 1995 and 1996, and (with some exceptions) every third Monday of each month from 1997 to present.
- The Remedial Investigation (RI) and the Feasibility Study (FS) reports were finalized and made available to the public in December 1999 and April 2000, respectively.
- Notice of availability of the Proposed Plan for site cleanup, notice of public meeting on the Proposed Plan, and announcement of the public comment period were published in the Bremerton Sun Newspaper on May 7, 2000. The announcement is attached as Appendix A.
- The Proposed Plan was mailed to all known interested parties on May 9, 2000.
- A public comment period was held from May 12, 2000 through June 13, 2000.
- A public meeting was held on May 16, 2000 to present the Proposed Plan to a broader community audience than those that had already been involved through the RAB. At the meeting, representatives from the Navy and Ecology answered questions about OU 8 and the remedial alternatives under consideration. The Navy also used this meeting to solicit a wider cross-section of community input on the reasonably anticipated future land use and potential beneficial groundwater used.
- The Navy's response to the formal comments received during the public comment period is included in Section 14: Responsiveness Summary.

In general, public comments were favorable to the Proposed Plan regarding OU 8. This decision document presents the selected remedial action for OU 8 of SUBASE Bangor in Silverdale, Washington. The decision is based upon evidence in the administrative record and was chosen in accordance with the Washington State Model Toxics Control Act (MTCA); CERCLA, as

amended by SARA; and to the extent practicable, the National Contingency Plan (NCP), and complies with applicable or relevant and appropriate federal, state, and local laws and regulations.

The Administrative Record is on file at the following location:

Engineering Field Activity Northwest (EFANW)
Naval Facilities Engineering Command
19917 Seventh Avenue NE
Poulsbo, Washington 98370
(360) 396-0243
Point of Contact: Ms. Julie Werder

The Information Repositories are in the following locations:

Central Kitsap Regional Library
1301 Sylvan Way
Bremerton, Washington 98310
(360) 377-7601

SUBASE Bangor Branch Library
Naval Submarine Base Bangor
(Base access is required)

Kitsap Public Utility District
1931 Finn Hill Road
Poulsbo, Washington 98370
(360) 895-5777

4. SCOPE AND ROLE OF OPERABLE UNIT

The sites listed in the SUBASE Bangor FFA were organized into seven operable units based on geographic location, suspected contamination, or other factors. The locations of the operable units are depicted in Figure 1-1. The last operable unit, OU 8, was added to the FFA in 1994. A separate study was conducted for each operable unit to determine appropriate cleanup actions. This ROD addresses OU 8 and represents the final remedial action decision document for SUBASE Bangor. RODs have been signed for the following operable units:

ROD	Date Signed
OU 1	December 1991
OU 2	September 1994
OU 3	April 1994
OU 4	July 1994
OU 5	September 1993
OU 6	September 994
OU 7	April 1996

Ingestion of water extracted from the Shallow Aquifer at OU 8 poses a current and potential future risk to human health because EPA's acceptable risk range is exceeded, and concentration of contaminants are greater than the maximum contaminant levels (MCL) for drinking water as specified in the Safe Drinking Water Act (SDWA).

OU 8 includes contaminated groundwater on base that migrates off base from the PWIA and extends in a southeastern direction toward the Mountain View residential neighborhood, and contaminated soil that extends from a depth of 15 feet bgs to the water table. The contaminated soil is limited to the central portion of the PWIA, beneath the gasoline service station. OU 8 presents the final response action for SUBASE Bangor and addresses the principal threat at OU 8 through the removal and treatment of the light non-aqueous phase liquid (LNAPL) source material beneath the PWIA.

The downgradient edge of the groundwater contamination plume is located just south of Mountain View Road and is approximately 500 by 2,000 feet in size. The extent of groundwater contamination plume has not increased since 1995. The contamination has extended downward in the downgradient direction at a maximum depth of approximately 100 feet below ground surface (bgs). The horizontal extent of the contamination plume is identified by 1,2-dichloroethane (DCA) and benzene, which are the chemicals of concern (COCs) that pose the majority of risk at OU 8. The other COCs contributing to human health risk in groundwater, 1,2-dibromoethane (EDB), 1,1 dichloroethene (DCE), and toluene are also being addressed by this remedy. The target compound DCA is the most recalcitrant; therefore, its decay rate is the time-limiting factor for remediation.

Within and around the PWIA, a variety of soil removal and remedial actions were conducted, many of which were performed under the SUBASE Bangor underground storage tank (UST)

program. In December 1999, confirmatory soil samples were collected beneath the PWIA to a depth of 15 feet bgs. The results indicate that the soil has been remediated to meet Ecology's cleanup levels. In February 2000, Ecology notified SUBASE Bangor that no further action is necessary to clean up the soil beneath the PWIA to a depth of 15 feet bgs. On March 28, 2000 the SVE system was shut down and put into standby mode. However, the residual contaminated soil from 15 feet bgs to the water table cannot be properly characterized and remedial alternatives cannot be fully evaluated. LNAPL represents an ongoing source contributing to the residual soil contamination. Natural attenuation and biodegradation, once the LNAPL has been removed to the extent practicable, may indirectly address the cleanup of residual contaminated soil.

Two removal actions were initiated by the Navy at OU 8 to prevent human exposure to VOCs in groundwater following the discovery of VOCs in an off-base water supply well. In 1995, the first time-critical removal action was initiated to supply Mountain View residents with an alternative drinking water supply. In 1997, the Navy initiated the second removal action to prevent further off-base migration of VOC contaminated groundwater. To accomplish this, the Navy operated and maintained a groundwater containment system from May 1997 through December 1999. The system pumped contaminated groundwater from the aquifer using two extraction wells located along the base boundary. The extracted groundwater was sent to an air stripper tower where VOCs were removed from groundwater. The treated water was reintroduced to the aquifer through two reintroduction wells.

As part of the OU 8 remedial investigation/feasibility study (RI/FS), computer models were developed to evaluate the ability of the containment system to minimize groundwater contamination from migrating off base and to evaluate the rate of natural attenuation processes to achieve the cleanup goals. The results from the model indicate that the containment system did not significantly remove VOCs from groundwater as compared to VOCs removed by natural attenuation and biodegradation processes. The model, based upon 1998 data, predicted the future benzene and DCA concentrations in the off-base portion of OU 8 will meet drinking water standards within 10 years, or by 2008. In addition, the rise in the water table in the vicinity of the reintroduction well (R2) has limited infiltration capacity of this well, thereby reducing the operational efficiency of the groundwater containment system. As a result, the containment system was shut down in December 1999.

Through the final remedy for OU 8, monitored natural attenuation will be used to evaluate the degradation of COCs in groundwater; free-product recovery will be used to address the principal threat, LNAPL; and institutional controls will be used to preclude human exposure to or use of contaminated groundwater until cleanup goals are achieved. Monitored natural attenuation includes, biodegradation sorption, dispersion, dilution volatilization and the chemical or biological stabilization or destruction of contaminants.

5. SITE CHARACTERISTICS

This section presents a comprehensive overview of the site including surface and subsurface hydrogeologic settings and previous removal actions at OU 8.

5.1 PHYSIOGRAPHIC SETTING

SUBASE Bangor is located in the west-central portion of the Kitsap Peninsula, approximately 1.5 miles west of Poulsbo, Washington. The base covers over 7,000 acres, with approximately 4.53 miles of shoreline on the east side of Hood Canal. This portion of Kitsap County lies within a physiographic area designated the Western Upland Plateau.

SUBASE Bangor can be divided into three physiographic areas: the upland plateau of the northern and eastem parts of the base, the remnant glacial till plain to the southwest, and the estuarine and marine environments of Hood Canal. The upland plateau consists of flat topped ridges ranging from 300 to 500 feet in elevation. The western margin of these ridges is cut by post-glacial ravines which discharge to Hood Canal (Figure 5-1). The southern end of the base consists of a glacial till plain characterized by several north-south trending drumlins. Most of this area, including all of OU 8, is drained by Clear Creek, which flows south to Dyes Inlet and eventually to Puget Sound. The marine and estuarine environment includes several freshwater wetlands adjacent to the tidal shores of Hood Canal. Most of these wetland areas are fed by groundwater springs that discharge at about the 225 feet level along the westem margin of SUBASE Bangor.

5.2 ECOLOGICAL CONDITIONS

SUBASE Bangor is host to three major ecosystems including mixed evergreen forests, freshwater wetlands, and tidal shores. Most of the developed land is concentrated in the southern half of the base, which includes shopping, restaurant and housing facilities, and the PWIA. The Strategic Weapons Facility, Pacific (SWFPAC) occupies much of the central portion of the base, while waterfront facilities are distributed along the entire shoreline area. The northern section of the base is densely forested, and mostly undeveloped.

The wooded areas at SUBASE Bangor are typical of second growth forests in the region, and are dominated by Douglas fir, western hemlock, and western red cedar, with red alder being the most common deciduous tree species.

SUBASE Bangor contains four significant freshwater wetland areas: Wilkes Marsh, located in the northeast comer of the base, is a natural feature; and Devils Hole, Cattail Lake and Hunters Marsh which are man-made features (Figure 5-1). These areas are classified as Category I and II wetlands in Washington's four-tier rating system. Additional smaller wetlands are scattered throughout the base, including wet areas along Clear Creek in the Mountain View area. Based on the SUBASE Bangor wetland designation map, there are no delineated wetlands at or adjacent to OU 8.

The tidal shores of Hood Canal are present along the northwest perimeter of the base. Beaches are typically composed of sand and gravel size material with boulder riprap present in many areas for erosion control.

5.3 REGIONAL GEOLOGY

Kitsap County lies within the Puget Sound Lowland, a broad structural trough filled with unconsolidated sediments of Quaternary age overlying Tertiary bedrock. Several continental ice sheets advanced and retreated across the region during the Quaternary period, resulting in the non-uniform deposition of glacial and nonglacial sediments. The Fraser glaciation was the most recent episode, of which the Vashon Stade was the most extensive. It was during this time period that the near-surface water bearing strata within the study area were deposited.

In general, ten stratigraphic units have been identified which are significant to understanding the geology and the hydrogeologic system in Kitsap County. Table 5-1 provides a brief summary of geological units from the youngest to the oldest. Figure 5-2 depicts a generalized geologic cross-section through SUBASE Bangor.

5.4 OU 8 GEOLOGY

Environmental investigations at OU 8 have encountered construction fill, Vashon Till, Vashon Advance Outwash, and Lawton Clay. Figure 5-3 depicts geologic cross-section beneath OU 8. Construction fill material is widely distributed throughout the vicinity of the PWIA. Beneath the asphalt roadways and parking surfaces, compacted sandy fill is typically present to depths of two or three feet. In addition, there are numerous underground storage tanks throughout the PWIA, particularly around the gasoline service station at Building 1204. The gasoline service station is referred to as the PWIA service station. These tanks are typically surrounded by coarse grain backfill and pea gavel that extends outward three or four feet from the perimeter of the tank, and to depths of 10 to 15 feet. Because construction fill has not been compacted to the extent of the native glacial soils, these materials tend to be significantly more porous and permeable than the till deposits that surround them. In addition, non-engineered fill was also encountered that contained a variety of materials including wood, metal and brick fragments in a small portion in the northwestern corner of the PWIA. These fill materials are present to a depth of 12 feet.

Throughout most of OU 8, the Vashon Till is exposed at the surface, and typically varies from 20 to 40 feet thick with a basal elevation of about 255 feet above mean sea level (msl). However, in the PWIA, the contact between the Vashon Till and the underlying alluvial deposits was encountered at depths ranging from 15 to 45 feet bgs (270 feet to 240 feet msl). Vashon till has topographic relief of up to 50 feet. At OU 8, the Vashon Till typically consists of a very dense, gray to brown, well-graded (poorly sorted) mixture of silt, sand, gravel and cobbles. Matrix supported gravel typically comprises about twenty percent of the till, with sands making up the remainder.

Underlying the till at OU 8 is the Vashon Advance Outwash (Qva) that hosts the shallow, unconfined aquifer system. This geological unit was the focus of the RI/FS for OU 8 and is

referred to as the Shallow Aquifer. Outwash deposits are typically 100 to 130 feet thick in OU 8, but regional data indicate rapid thinning to the east where outwash deposits are locally absent in the vicinity of Clear Creek. Overall, the outwash deposits at OU 8 consist of a coarsening upward sequence of sand, silt, and gravel, with silt and silty sand predominating in lower sections just above the Lawton Clay.

The Lawton Clay underlies the Vashon Advance Outwash, and is typically 40 to 80 feet thick, although in some areas its thickness exceeds 200 feet. It is a locally extensive unit that has been identified throughout SUBASE Bangor, northern Kitsap County, and the Seattle area. The Lawton is exposed in outcrop at various locations along Hood Canal. The top of the Lawton Clay is an irregular erosional surface with local relief of up to 30 feet. However, the attitude of the Lawton (i.e., strike and dip) is unknown in the vicinity of OU 8. Where locally exposed in outcrop, the Lawton-outwash contact is at an elevation of approximately 145 feet above msl.

5.5 SURFACE WATER HYDROLOGY

Clear Creek is the most prominent surface water feature at OU 8 and provides drainage for the southeastern portion of SUBASE Bangor (Figure 5-1). There are three principle branches of Clear Creek, which join together approximately two miles southeast of the study area, and flow into the north end of Dyes Inlet in Silverdale, Washington.

The PWIA is near the headwaters of the central branch of Clear Creek. The central branch is an ephemeral stream that is confined to storm water culverts beneath the paved surfaces in the PWIA. While flowing through the Mountain View residential area the central branch follows a naturalized drainage swale.

The surface water divide between the Hood Canal and the Puget Sound basins runs through the east-central portion of SUBASE Bangor, approximately one mile west of OU 8. The surface water divide appears to roughly coincide with the groundwater divide.

5.6 GROUNDWATER HYDROLOGY

The geologic and hydrogeologic conditions at OU 8 have been characterized through the drilling and installation of approximately one hundred groundwater monitoring wells. All of these wells have been completed in the Shallow Aquifer. The Shallow Aquifer is approximately 120 feet thick throughout most of OU 8 where the depth to groundwater ranges from five feet to 65 feet bgs depending on the land surface elevation. In the PWIA, the current depth to groundwater is approximately 22 feet bgs and occurs at the contact between the Vashon Till and the alluvial outwash deposits. The seasonal fluctuation in the water table is typically two or three feet, with low water levels commonly occurring in September and high levels in May. However, due to record high rainfalls throughout much of the Puget Sound basin in 1996 and 1997, water table elevations at OU 8 have risen four to eight feet above the typical level.

Throughout OU 8, the Lawton Clay underlies the Shallow Aquifer. The Lawton Clay is a regionally extensive aquitard that effectively isolates the near-surface groundwater system from

the deeper municipal water supply aquifers. A geologic cross-section depicting the Shallow Aquifer and monitoring wells with static water level measurements (from 1996) is presented in Figure 5-3. The general direction of the horizontal component of groundwater flow in the Shallow Aquifer is to the southeast.

The vertical component of groundwater flow in the Shallow Aquifer is in the downward direction. The vertical gradients vary significantly between well clusters, which reflects the heterogeneity of the aquifer materials and the variable recharge rates across OU 8. Vertical hydraulic conductivities in the Shallow Aquifer were estimated to be approximately 10 times less than associated horizontal conductivities due to the anisotropy (i.e., silty layering) of the Vashon Advance Outwash.

Aquifer pumping tests were performed at OU 8 in 1996. Table 5-2 summarizes the calculated and measured values of the Shallow Aquifer properties.

5.7 PREVIOUS REMOVAL AND REMEDIAL ACTIONS

This section summarizes prior removal and remedial actions relevant to OU 8. Two time-critical removal actions were implemented at OU 8 after VOC were detected in an off-base residential supply well. In addition, a variety of removal and remedial actions have been conducted under the SUBASE Bangor UST program within and around the PWIA from 1986 through 2000.

5.7.1 OU 8 Removal Actions

Two removal actions have been initiated at OU 8 to prevent potential human exposure to VOC in groundwater. In 1995, the first time-critical removal action was implemented to supply Mountain View residents with an alternate drinking water source. The Navy connected the Mountain View residents in the impacted area to a municipal water supply to prevent human exposure to contaminated groundwater and negotiated water use agreements with private landowners. The Navy paid the cost of an estimated three years of water service on a one-time lump sum basis. There is no plan for the Navy to connect additional private properties to the municipal water supply. The water use agreements are recorded with the Kitsap County Auditor office and are legal agreements that "run with the land," and are legally binding on subsequent private property owners.

In 1996, the second removal action was implemented to prevent further off-base migration of VOCs contaminated groundwater by installing a groundwater containment system. The containment system consisted of a groundwater pump and treat (P&T) system. Figures 5-4 and 5-5 depict the layout and schematic flow diagram of the P&T system at OU 8. The P&T system involves pumping groundwater from two extraction wells (E1 and E2) located near the base boundary, removing the VOCs in an aboveground treatment plant, and returning the treated groundwater to the aquifer through two reintroduction wells (R1 and R2). Each extraction well was constructed to pump between 30 to 100 gallons per minute (gpm). The combined pumping rate from each well was reduced to 45 gpm or a combined flow rate of 90 gpm. Results from the natural attenuation studies and the computer modeling performed as part of the feasibility study (FS) indicate that the P&T system did not significantly remove VOCs from groundwater as

compared to VOCs removed by natural attenuation. Therefore, the P&T system was shut down in December 1999.

5.7.2 Underground Storage Tanks Removal in the PWIA

As part of the SUBASE Bangor UST Program, tightness tests were performed on USTs in the PWIA to identify potential leaks from tanks and associated piping systems. Through this program, several USTs have been removed or abandoned in place to prevent further releases to the subsurface. Releases from the tanks and associated piping systems were documented. Figures 5-6 depicts abandoned and existing USTs at OU 8. Figure 5-7 depicts the approximate location of the currently inactive free-product recovery system. Figure 5-8 depicts subsurface soil and groundwater sample locations in the PWIA.

Closure of UST 1202

Tank 1202 was a 2,000-gallon waste oil tank located immediately south of Building 1202 (Figure 5-6). During the tank removal in September 1994, petroleum contaminated soil was observed surrounding the tank and was removed. However, since the tank had passed a tightness test, it was suspected that improper product handling (i.e., tank overfilling or spills during pump out) caused the soil contamination. The results from the post-excavation soil sampling indicated total petroleum hydrocarbons (TPH), Polychlorinated Biphenyl's (PCBs), polycyclic aromatic hydrocarbons (PAHs), total metals, total halogenated organics, and select Toxicity Characteristic Leaching Procedure (TCLP) analytes such as VOCs and lead, are below the laboratory reporting limits. Therefore, no further action was taken.

Closure of UST 1204-4

Tank 1204-4 was a 2,000-gallon waste oil tank located immediately south of Building 1014 (Figure 5-6). The tank, installed around 1977, was removed in September of 1993. Following tank removal, the results from the post-excavation soil samples indicated TPH below the MTCA Method A cleanup levels. Therefore, no further action was taken.

Closure of UST 1206

Tank 1206 was a 5,000-gallon diesel tank located northwest of Building 1014 (Figure 5-6). During the tank removal in 1992, TPH was detected at concentrations up to 900 mg/kg in excavated soils. All petroleum-contaminated soil was reportedly removed during the excavation.

Closure of UST 1038

Tank 1038 was a 20,000-gallon diesel tank located immediately east of Building 1038 (Figure 5-6). The tank was discovered in 1995. Sometime prior to 1995, the tank was abandoned; however, some void spaces were left in the tank. During the tank closure in 1996, petroleum contaminated soil surrounding the tank was excavated, stock-piled, and later backfilled into the excavation. Samples of the stock-piled soil contained concentrations of TPH up to 2,200 mg/kg (as diesel), and 500 mg/kg (as gasoline).

USTs at Former Building 15

In August 1996, under contract with the Navy, Shannon & Wilson performed a subsurface investigation into the status of suspected USTs at several locations in the PWIA, including two heating oil and/or diesel tanks at the former steam plant (Building 15). Figure 5-6 depicts the historical location of USTs at former Building 15. No USTs were encountered during the 1996 excavation. The USTs were presumably removed during the demolition of Building 15. However, an abandoned piping vault was encountered at a depth of 5 feet. During excavation, petroleum contaminated soil was encountered at concentrations that exceeded MTCA Method A cleanup levels. Gasoline range hydrocarbons were detected at concentrations up to 250 mg/kg, and diesel was identified at concentrations up to 460 mg/kg. Although the excavation was backfilled with clean soil from the storm water detention pond, petroleum contaminated soil still remains in the vicinity of the excavation(s).

USTs at Former Building 20

Under contract with the Navy, Shannon & Wilson also performed a surface geophysical survey in the vicinity of the former service station at Building 20 in an effort to identify abandoned USTs. Although the survey did not identify evidence of an intact UST, demolition debris appeared to be backfilled into the UST excavation. The gasoline tanks at Building 20 were presumably removed when the service station was demolished.

Other USTs

In addition to the UST closures described above, other USTs in the PWIA have been removed or decommissioned. The tank shown at location "C" on Figure 5-6 is the suspected site of a removed gasoline tank associated with the old filling station at Building 20. However, the exact location of this tank and its contents have not been determined. Location "E" is the site of abandoned or removed tanks associated with the former steam plant (Building 15). These tanks could have contained up to 50,000 gallons of diesel and Bunker oil. Both of these areas were investigated using ground penetrating radar (GPR). The results of the GPR survey indicated that these tanks are no longer present.

Tank 1012, Tank 1025, and the fuel storage tanks near the service station are currently operational, and are monitored as required under the SUBASE Bangor UST Program (Figure 5-6). Tank 1012 is a 6,000-gallon waste oil tank. It contains waste oil from the oil/water separator in Building 1012. No leaks or spills are known to be associated with this tank.

Tank 1025 is an 8,000-gallon waste oil tank. It contains waste oil from the oil/water separator in Building 1025. There are no reports of leaks and spills associated with this tank.

For fuel storage, the service station at Building 1204 currently utilizes a 20,000-gallon diesel tank (Tank 1204-5, formerly unleaded gasoline) and three 15,000-gallon unleaded gasoline tanks (Tanks 1204-1, 1204-2, and 1204-3). Figure 5-6 depicts the USTs underneath the service station area.

Product Release: UST 1204-5

Tank 1204-5 is a 20,000-gallon unleaded gasoline tank that was installed at the PWIA service station (Tank 1204-5) in 1979, and was operated until 1986 when a leak was discovered in an underground fuel line (Figures 5-6 and 5-7). The leak was immediately repaired; however, an estimated 20,000 gallons of fuel was released into the subsurface between 1982 and 1986. This release is the suspected source for the majority of the petroleum related chemicals in OU 8 groundwater.

In July 1986, nine monitoring wells (MW01 through MW09) were installed in the vicinity of Building 1204 to assess the groundwater conditions in the area (Figure 5-8). LNAPL was observed in MW01 (3.07 feet thick), MW02 (1.07 feet thick), and in MW03 (0.9 feet thick), while hydrocarbon odors were noted in MW04 and MW05.

5.7.3 Product Recovery System

In August 1986, a free-product recovery system was installed in the PWIA service station area. The recovery system consisted of three product recovery wells equipped with pneumatic pumps (RW1, RW2, and RW3). The wells were installed in the area of known floating free product (Figure 5-7). Extracted free product and groundwater is pumped to an oil/water separator. Petroleum from the oil/water separator is pumped into an above ground holding tank, while the wastewater is discharged into the sanitary sewer. The system was shut down in November 1998. Approximately 6,000 gallon of LNAPL has been recovered from an estimated 20,000 gallons released.

5.7.4 SVE System

In 1994, a combined SVE and bioventing system was installed in the vicinity of the gasoline release at the PWIA service station to remediate petroleum-contaminated soil. The schematic layout of the SVE/bioventing system is shown on Figure 5-7.

The system consisted of a combination of 15 SVE wells (VS1 through VS15), four air sparging wells (AS1 through AS4), and one vent well (VS16). All of the SVE wells were manifolded into a blower, while the sparging wells were connected to a compressor. Extracted soil vapor was piped to a regenerative thermal oxidation unit (RETOX®) for treatment. In March 1996, the above ground components of the system were dismantled, but the vapor wells and underground piping were left in place.

The SVE system was restarted in January 1997 using the original in-ground components of the system. New aboveground system components were added, including a moisture knockout tank, a blower, a catalytic oxidizer, and a control unit. A process and instrumentation diagram of the SVE system is shown in Figure 5-9. Since the start of operation in January 1997 through March 2000, the SVE system has removed approximately 35,000 pounds of petroleum hydrocarbon vapor.

5.7.5 SVE Tests

Prior to the 1997 soil vapor extraction (SVE) system modifications, SVE pilot tests were conducted (November 1996) in the vicinity of the PWIA service station to determine the feasibility of implementing SVE to remediate petroleum contaminated soils in the area. During the SVE tests, LNAPL was observed in numerous wells located in the vicinity of Building 1204. The presence of LNAPL in vapor wells where it had not previously been identified was likely due to abnormally high groundwater levels associated with record rainfall in 1996. As an interim measure, LNAPL was removed from the wells through hand bailing through the end of December 1996.

Results of the SVE pilot tests indicated that an optimized system could remediate the petroleum contaminated subsurface soils in the vicinity of the PWIA service station, but LNAPL may require a separate recovery system.

5.7.6 Closure of Clear Creek Grocery UST

The Clear Creek Grocery is located off-base on the southwest corner of the intersection of Clear Creek and Mountain View Roads (Figures 1-2 and 5-10). From 1992 to 1994, the owner of Clear Creek Grocery conducted a limited site characterization study, a gasoline UST closure, and a petroleum contaminated soil removal at the grocery store/service station. The former USTs at the Clear Creek Grocery represent the only documented release of petroleum fuels in the Mountain View residential neighborhood.

In 1992, during the repair of a shallow gasoline line at the grocery store/service station, petroleum hydrocarbons were detected in the soil at concentrations exceeding the MTCA Method A cleanup levels. This led to a limited site investigation later that year. The results from the three test pits sampled during this investigation indicated petroleum hydrocarbons below Method A cleanup levels.

In 1993, the owner of Clear Creek Grocery removed three steel USTs from the north side of the property. Soil samples collected during the removal contained petroleum hydrocarbons at concentrations up to 12,000 mg/kg. Contaminated soil was removed, and the excavation was backfilled with clean material.

In 1993 and 1994, a subsurface investigation was performed to characterize the groundwater conditions at the site and to evaluate residual soil contamination in the area of the release. Four soil borings were installed. Three of the soil borings were completed as groundwater monitoring wells (B1 and MW01 through MW03). The analytical results of soil and groundwater indicated benzene, toluene, ethylbenzene, and xylenes (BTEX); TPH as gasoline (TPH-G) and total lead below the MTCA Method A cleanup levels. The characterization report recommended additional remedial activities at the site including installing a monitoring well downgradient of the UST excavation. No information is currently available to determine if the recommendations were accepted and/or implemented by the owners.

5.8 SAMPLING STRATEGY

This section summarizes the field investigation and describes the rationale, methods, and procedures used to determine the physical and chemical characteristics of OU 8 during the OU 8 remedial investigation (RI). The OU 8 RI was conducted in the summer of 1996. The RI results are presented in the RI report. A total of 15 new monitoring wells were installed, and groundwater samples were collected from 75 wells (60 existing and 15 new wells) as part of the RI.

Previous environmental investigations at the PWIA detected trace levels of chlorinated VOCs in several subsurface soil samples. The history of any chlorinated solvent release in the PWIA is unknown. However, it is reasonable to assume that any chlorinated solvent release occurred prior to mid-1970s when: (1) environmental and hazardous materials awareness was considerably less than it is today; (2) the PWIA was largely unpaved; and (3) demilitarization activities were peaking in support of the Vietnam War. Contour maps of chlorinated VOC concentrations in groundwater clearly indicate initial releases at the PWIA where the highest concentrations of chlorinated VOC have consistently been detected in groundwater samples.

The RI field sampling program was designed to accomplish the following specific objectives:

- Identify chlorinated VOC source areas in the PWIA, if present;
- Further define the vertical extent of VOCs in groundwater;
- Establish groundwater monitoring locations east of Clear Creek Road;
- Determine the current extent and concentrations of VOC in groundwater; and
- Collect additional information to support the risk assessment, the FS, and the contaminant transport computer modeling effort.

During the OU 8 field investigation, samples of groundwater, subsurface soil, soil vapor, groundwater seep, and sediment (surface soil from Clear Creek) were collected from the locations shown in Figures 5-11 and 5-12. In addition, groundwater samples were also collected from all of the OU 8 monitoring wells shown in Figure 5-13. Table 5-3 summarizes the rationale for these sampling locations.

5.9 NATURE AND EXTENT OF CONTAMINATION

This section summarizes the results of subsurface soil, soil vapor, groundwater, and groundwater seep and sediment samples collected during the RI and the on-going groundwater monitoring program at OU 8. The VOC and semi-volatile organic compound (SVOC) detections in soil and groundwater were compared to the most conservative chemical-specific screening levels at the time of the RI, which are the MTCA Method B Levels. Screening levels are used to evaluate levels of chemical contamination and to establish cleanup requirements under WAC 173-340 (Ecology 1996a). For noncarcinogenic and carcinogenic substances, the soil screening levels in

MTCA were developed using Ecology's risk criteria for ingestion of soils. For certain chemicals where risk-based soils cleanup levels cannot be established or where such levels in soils may not be adequately protective of groundwater quality, MTCA sets the soil cleanup level at 100 times the groundwater cleanup levels for those chemicals. Sediment samples were screened to the soil values of MTCA Method B. MTCA Method B values are set using a site risk assessment for single substances in single media. As specified in the MTCA Cleanup Levels and Risk Calculations (CLARC II) Update, the MTCA Method B values were developed from:

- Maximum contaminant levels (MCLs), maximum contaminant level goals (MCLGs), secondary maximum contaminant levels (SMCLs), and ambient water quality goals (AWQGs),
- Formula values based on human health,
- Method A values,
- Levels to protect the environment (e.g., levels which will prevent migration of hazardous substance from one medium to another with resultant violation of a cleanup level in the second medium or levels which will protect unique site characteristics,
- Levels based on natural background levels of hazardous substances, and
- Practical quantification limit (PQL) [The PQL is the lowest concentration of an analyte that can be reliably measured within specified limits of precision and accuracy during routine laboratory operating conditions. PQLs can be used to estimate or evaluate the minimum concentration at which most laboratories can be expected to reliably measure a specific chemical.]

5.9.1 Subsurface Soil Samples

In order to determine if an active source of contamination existed in the PWIA, samples of subsurface soil and soil vapor were collected from 12 newly installed wells (8MW38 through 8MW49). Additional soil vapor samples were also collected from five existing vapor extraction wells (VS6, VS9, VS11, VS13, and VS16), and from five existing monitoring wells (MW03, MW04, MW05, MW06, and MW07). Subsurface soil samples were analyzed for VOC and semi-volatile organic compounds (SVOC), while soil vapor samples were analyzed for VOCs only. Soil samples were also collected during the installation of new wells 8MW50 through 8MW52.

Table 5-4 summarizes the number of samples collected, number of detections, minimum and maximum detected VOC and SVOC concentrations in subsurface soils. A total of 13 VOCs were detected in the subsurface soil samples collected as part of the OU 8 source area investigation. No VOCs were detected in subsurface soils at concentrations exceeding the MTCA Method B cleanup levels. Based on the results of the subsurface soil samples collected

during the OU 8 source area investigation, there is no evidence for an active source of chlorinated VOCs in the soils beneath the PWIA.

Four of the 15 SVOCs detected in subsurface soils were reported at concentrations exceeding the MTCA Method B cleanup levels. These four SVOCs are benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and chrysene. These SVOCs are classified as carcinogenic PAH compounds.

Non-chlorinated VOCs were detected in all soil vapor samples collected during the OU 8 tests at concentrations ranging from trace amounts to percent levels. Most of these chemicals are components of petroleum, and are likely related to the gasoline release at the PWIA service station. Elevated concentrations of BTEX compounds were detected in soil vapor samples collected from wells located in the central and the south-central portions of the PWIA. The area of elevated petroleum compounds in soil vapor begins in the vicinity of UST 1204-5 and extends downgradient to the southeast for a distance of approximately 500 feet.

A total of six chlorinated VOCs were detected in the soil vapor samples collected during the OU 8 source area investigation. They are DCA; 1,1-dichloroethene (DCE); 1,1,1-trichloroethane (TCA); vinyl chloride; chloroform; and carbon tetrachloride.

Based on the results of the subsurface soil and soil vapor samples collected during the OU 8 source area investigation, and sample results from previous investigations, the following conclusions can be drawn:

- An active source of chlorinated VOCs was not identified in the subsurface soil beneath the PWIA. The low concentrations of chlorinated VOCs reported in several soil vapor samples are not necessarily indicative of a source, and is attributable to evaporation of these chemicals from the water table.

- Petroleum related VOCs were detected in subsurface soil samples collected from depths of 25 to 40 feet bgs in the south central portion of the PWIA. The presence of these chemicals in the groundwater smear zone and the top 10 feet of the aquifer suggests that they are related to the gasoline release at UST 1204-5.

- The presence of SVOC approximately 250 feet upgradient of the PWIA service station suggests that they are not related to the fuel release at the gasoline service station but most likely to past maintenance activities such as parts degreasing.

- VOCs and SVOCs were not detected in the subsurface soil sample collected at 120 feet bgs from 8MW50.

5.9.2 Groundwater Samples

A total of 75 monitoring wells (60 existing and 15 new wells) were sampled as part of the remedial investigation to assess the extent of contamination in OU 8 groundwater (Figure 5-13).

Groundwater samples were analyzed for VOCs and SVOCs, and were field tested for a variety of water quality parameters.

Volatile Organic Compounds

Table 5-5 summarizes the number of samples collected, number of detections, minimum and maximum detected concentrations, and the reference values used for screening in the RI (EA 1999). A total of 26 VOCs were detected in the groundwater samples. In the RI, eleven VOCs were detected at concentrations exceeding the MTCA Method B cleanup levels. The distribution and concentration of VOCs in groundwater was similar to the sampling results obtained from the on-going groundwater monitoring program at OU 8. In 1999, only five VOCs were detected at concentrations exceeding the MTCA Method B cleanup levels. They are benzene, DCA, DCE, 1,2-dichloropropane, and 1,1,2-trichloroethane. Based on the results of groundwater monitoring from 1995 through 1999, benzene and DCA were the most frequently detected chemicals at OU 8. They were detected at the highest concentration relative to their MTCA cleanup levels.

Semivolatile Organic Compounds

Table 5-6 summarizes the number of samples collected, number of detections, minimum and maximum detected concentrations, and the MTCA Method B reference value used for screening in the RI. A total of 12 SVOCs were detected in the groundwater samples collected during the OU 8 remedial investigation. However, no SVOCs were detected in OU 8 groundwater at concentrations exceeding the MTCA Method B cleanup levels. The most frequently detected SVOCs were 2-methylnaphthalene, phenol, benzoic acid, bromacil 2-methylphenol, and 4-methylphenol.

5.9.3 Groundwater Seep and Sediment Samples

Groundwater seep and sediment (surface soil) samples were collected, in July-August 1996, from three locations along the west bank of the main branch of Clear Creek (Figure 5-12). All detections of VOCs and SVOCs in groundwater seep and sediment samples collected are shown in Table 5-7. No VOCs or SVOCs were detected in groundwater seep or sediment samples at concentrations exceeding the MTCA B cleanup levels.

Six organic chemicals were detected at the upgradient/background location SP3. The presence of these chemicals at this location suggests that the chemicals observed in the seep and sediment samples are not related to OU 8.

5.9.4 LNAPL

Figure 5-14 depicts the extent of LNAPL beneath the PWIA as of September 1998. LNAPL has been observed in several wells located in the vicinity of the PWIA service station. During the OU 8 groundwater sampling, sheens and/or strong petroleum odors were observed in wells MW03, MW04, MW08 and 28MW01. In October 1996, LNAPL was observed in a newly installed well (8MW49) located approximately 100 feet south of its previous known extent. The LNAPL was identified to be gasoline and appears to be related to the releases from tank 1204-5.

Based on field measurements, it is estimated that a maximum of approximately 13,000 gallon of LNAPL remains beneath the PWIA.

5.9.5 Horizontal Extent of VOC in Groundwater

Figures 5-15 through 5-18 depict the horizontal extent of benzene from 1995 through 1998. Figures 5-19 through 5-22 depict the horizontal extent of DCA from 1995 through 1998. Although there is some minor boundary fluctuation that would be expected, the horizontal extent of groundwater contamination has not significantly increased over the past several years. The plume is stable. The downgradient edge of groundwater contamination is located just south of Mountain View Road, and the overall dimension of the contaminant plume is approximately 2,000 feet by 500 feet.

The horizontal extent of DCA in groundwater clearly indicates a potential initial release(s) of chlorinated VOCs in the PWIA, where the highest concentrations of these chemicals have been observed in groundwater since 1994. More chlorinated compounds such as tetra and tri-chlorinated compounds are detected beneath the PWIA. Less chlorinated compounds such as dichlorinated compounds are detected beneath the PWIA, along the base boundary, and Mountain View residential area.

No VOCs or SVOCs were detected in downgradient monitoring wells 8MW15, 8MW51 or 8MW52. This data suggest that the extent of VOC in the Shallow Aquifer is not increasing, and contaminants are not migrating beyond the vicinity of Mountain View Road.

5.9.6 Vertical Extent of VOC in Groundwater

Figures 5-23 and 5-24 are cross sections that depict the vertical extent of benzene and DCA, respectively, in the Shallow Aquifer in 1996. In the PWIA, the highest VOC concentrations were detected in the shallow portion (top 30 feet) of the Shallow Aquifer. To the southeast, along the base boundary and Mountain View Road, the highest VOC concentrations were detected in the intermediate depths (middle 40 feet) of the Shallow Aquifer. These data show that VOCs have migrated into deeper portions (deeper than 70 feet) of the Shallow Aquifer in the downgradient direction.

In the PWIA, where the vertical hydraulic gradient is greatest, VOCs have migrated downward to the deeper portions of the Shallow Aquifer. Along the base boundary, the highest concentrations of VOCs were detected approximately 35 feet deeper into the aquifer. In the Mountain View residential area where vertical groundwater gradients are considerably less, VOCs remained confined to intermediate aquifer depths, with little downward migration.

Petroleum related VOCs (represented by benzene) show greater vertical extent than the chlorinated VOCs (represented by DCA). In the PWIA, petroleum related VOCs were detected in the intermediate and deep portion of the Shallow Aquifer. This indicates that the entire thickness of the Shallow Aquifer beneath the PWIA may have been impacted as a consequence of the gasoline release from tank 1204-5.

Chlorinated VOCs are restricted to a relatively narrow interval of aquifer thickness. In the PWIA, chlorinated VOCs were confined to the shallow portion and were not detected in the intermediate or deep portions of the Shallow Aquifer. In the off-base portion of OU 8, chlorinated VOCs were restricted to the intermediate portion and were not reported in the shallow or deep portions of the Shallow Aquifer.

5.10 CHEMICALS OF CONCERN

The remedial investigations for OU 8 included sampling and chemical analysis, geophysical investigations, and soil vapor screening. Soil borings were drilled at most of OU 8 to collect subsurface soil samples, and some soil borings were completed as monitoring wells for groundwater characterization. Groundwater seep and sediment (surface soil) samples were also collected from Clear Creek. In general, soil and groundwater samples were analyzed for EPA target compounds, ordnance compounds, herbicides, and water quality parameters. EPA target compounds are VOCs, SVOCs, pesticides, and PCBs.

Sampling results were screened against risk-based screening concentrations (RBSCs) and MCLs. For OU 8, RBSCs are EPA Region IX Preliminary Remediation Goals (PRGs), EPA Region III Risk-Based Concentrations (RBCs), and the MTCA Method B values. If the maximum concentration of a chemical exceeded the lowest value among the RBSCs or its MCL, then that chemical was identified as a chemical of potential concern (COPC) at OU 8. COPCs were then carried through the risk assessment process. Those COPCs that were characterized as presenting an unacceptable risk to human health or the environment were identified as chemicals of concern. (COCS).

Two human health risk assessments were performed for OU 8. The first risk assessment was performed as part of the remedial investigation and is referred to as the original (1995/96) risk assessment. The data used in the 1995/96 risk assessment consisted of data collected from March 1995 through August 1996. The second risk assessment was performed as part of the feasibility study and is referred to as the 1998/99 risk assessment. The 1998/99 risk assessment focused on evaluating risks to future off-base receptors through groundwater consumption. The data used in the 1998/99 risk assessment consisted of data from January 1998 through January 1999, from selected wells at the base boundary and along Mountain View Road.

Table 5-8 summarizes on-base and off-base risk-based COCs identified for OU 8, and potential chemical-specific ARARs. Table 5-9 summarizes chemical-specific risks that exceed EPA criteria by pathway and receptor based on soil and groundwater data obtained during the remedial investigation in 1996. Table 5-10 summarizes chemical-specific risks that exceed EPA criteria by pathway and receptor based on groundwater data collected in 1998 and 1999.

5.11 CONCEPTUAL SITE MODEL

The primary concern at OU 8 is VOC contaminated groundwater, which has extended to approximately 2,000 feet long and 500 feet wide within the Shallow Aquifer. Contamination in the Shallow Aquifer has threatened the public drinking water supply wells located in the

Mountain View neighborhood. The secondary concern at OU 8 is the dissolution of VOCs from LNAPL beneath the PWIA service station into the groundwater. The LNAPL presents an ongoing source of groundwater contamination and contributes to the residual soil contamination.

A number of mechanisms exist by which chemicals at OU 8 can migrate from contaminated areas to other areas and other media. The movement of chemicals in the environment is a complex process subject to the physical and chemical properties of the chemical, and physical and biological characteristics of OU 8. A conceptual site model was developed to schematically display available information such as chemical sources, migration and exposure routes to aid in identifying potential risks to human health and the environment. Figure 5-25 depicts the conceptual site model developed for OU 8.

5.12 PRINCIPAL-THREAT AND LOW-LEVEL-THREAT WASTES

NCP Section 300.430(a)(1)(iii)(A) establishes an expectation that treatment will be used to address the "principal threats" posed by a site wherever practicable. Principal threat wastes are those "source materials" considered to be highly toxic or highly mobile that cannot be contained in a reliable manner, or would present a significant risk to human health or the environment should exposure occur. Low-level threat wastes are those source materials that generally can be reliably contained and that would present only a low risk in the event of exposure. The statutory preference for treatment as a principal element is satisfied if the principal threat at OU 8 is addressed through treatment.

The principal threats posed by OU 8 are from LNAPL beneath the PWIA service station. Previous actions aimed at addressing the principal-threat source material at OU 8 were installation of the product recovery system (Section 5.7.3) and soil vapor extraction system (Section 5.7.5). Through field measurements during the on-going groundwater monitoring program at OU 8, LNAPL is still present at OU 8. This contamination is considered a principal threat due to contaminant mobility from LNAPL to groundwater and the resultant toxicity in groundwater from VOCs.

The low-level threat waste at OU 8 is petroleum-contaminated soil beneath the PWIA service station at a depth of 15 feet bgs to the water table. Because the water table is presently at historic high level (approximately 22 feet bgs), most contaminated soil is below the water table. There are no human health risks related to exposure to subsurface soil. Human health risks associated with OU 8 are related to constituents in the groundwater. The LNAPL found at the site presents a significant ongoing source of COCs in groundwater and also contributes to residual soil contamination. A soil removal action to address contamination at these depths within the confines of a heavily developed PWIA would be extremely difficult, costly, and would not significantly minimize further groundwater contamination. Natural attenuation and biodegradation may be applicable for the soil once the LNAPL has been removed to the extent practicable. However, until that time, the residual soil contamination cannot be fully characterized and residual soil cleanup cannot be evaluated. Accordingly, the residual contaminants in soil from a depth of 15 feet bgs to the water table are not directly addressed in

this remedy. The status of the residual soil contaminants and the need for active remediation will be evaluated within the 5-year review process.

There are no principal threats associated with the groundwater contamination at OU 8 because groundwater contamination is generally not considered a source material, and therefore would not be characterized as a principal threat as defined by the NCP. However, VOC contamination in groundwater constitutes the primary risk remaining at OU 8 and is the current focus of the Navy's actions.

5.13 NATURAL ATTENUATION EVALUATION

During the Remedial Investigation, the Navy performed a two-phase groundwater investigation at OU 8 to evaluate the potential for remediation by monitored natural attenuation. Phase I groundwater sampling activities were conducted in October 1997 (EA 1998c), and Phase II sampling occurred in June 1998 (EA 1999b). During each phase, groundwater samples were collected from approximately 20 wells, and analyzed for a variety of chemical parameters that are indicative of various processes that naturally degrade chemical contaminants. This section describes the results of the natural attenuation evaluation, which was performed in accordance with the USEPA guidance document entitled Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water (USEPA 1998). Additional and specific guidance was obtained from the document entitled "Technical Guidelines for Evaluating Monitored Natural Attenuation of Petroleum Hydrocarbons and Chlorinated Solvents in Groundwater at Naval and Marine Corps Facilities" (US Navy 1998).

Natural attenuation processes include the biological, chemical or physical processes that act without human intervention to reduce the mass, toxicity, mobility, volume or concentration of contaminants. These processes include biodegradation, sorption, dispersion, dilution, volatilization; and the chemical or biological stabilization or destruction of contaminant chemicals. Processes that actually degrade or destroy chemical contaminants (i.e., biodegradation) are preferable to simple mass transfer or dilution mechanisms. Monitored natural attenuation is most appropriate as a remedial action alternative where groundwater plumes are in a stable or steady state condition (USEPA 1998). The USEPA defines monitored natural attenuation (MNA) as:

"*...the use of natural attenuation processes within the context of a carefully controlled and monitored site cleanup approach that will reduce contaminant concentrations to levels that are protective of human health and the environment within a reasonable time frame (USEPA 1998).*"

To demonstrate that remediation by natural attenuation is occurring at OU 8, a weight of evidence approach was presented (EA 1998c, 1999b) using a variety of supporting evidence as identified in several reference documents. The approach taken focused on identifying the following natural attenuation evidence:

- Plume stability,
- Redox zonation,

- Nutrients and food sources,
- Daughter product analysis, and
- Contaminant transport model.

The purpose of this section is to summarize the results of the MNA evaluation at OU 8. A general discussion of biodegradation is presented in Section 5.1.3 of the Final RI Report (EA 1999a), and the details of the MNA evaluation are provided in the Phase I (EA 1998c) and Phase II (EA 1999b) reports.

5.13.1 Biodegradation at OU 8

At OU 8, the PWIA contains ideal redox conditions for reductive dechlorination because of the abundance of petroleum hydrocarbon and chlorinated VOCs and the favorable anaerobic conditions created from biological decay of petroleum fuels. Downgradient of the PWIA where the groundwater becomes more oxygenated, the degradation of both petroleum hydrocarbon and reduced chlorinated VOCs can proceed under aerobic conditions in which both classes of chemical contaminants behave as electron donors.

Evidence indicates that the occurrence of reduced chlorinated VOCs such as DCA in OU 8 groundwater represents a degradation daughter product of trichloroethane (TCA), a common industrial solvent (EA 1998a). The groundwater data show DCA is distributed within the benzene plume and is at highest concentrations in locations corresponding to anaerobic groundwater conditions (EA 1999a).

During the natural attenuation evaluations, groundwater samples were collected from approximately 20 wells located throughout OU 8 (EA 1998c and 1999b). Figure 5-26 depicts the natural attenuation sampling locations. The distribution of these wells represent the variety of groundwater conditions present at OU 8 from the background well (8MW16) in the northwest corner of the study area, through the PWIA, past the base boundary and mountain View Road, to Clear Creek Road (8MW15) in the southeast portion of the study area. The weight of evidence approach was used to demonstrate that remediation by natural attenuation is occurring at OU 8. These evidences are presented in the following sections.

5.13.2 Plume Stability

Plume stability is one of the most important conditions required to successfully implement monitored natural attenuation as a remedial action alternative. Plume stability is identified by monitoring groundwater data for petroleum, VOCs and general water chemistry such as redox potential, pH, temperature, etc. At OU 8, DCA and benzene have been consistently detected at concentrations exceeding the regulatory screening criteria.

Figures 5-15 through 5-22 show the benzene and DCA contaminant plumes at OU 8 from 1995 through 1998. Based on the groundwater data, both the DCA and benzene plumes appear to be stable. The groundwater data also indicate that the DCA and benzene concentrations have been declining in groundwater samples collected from wells in the Mountain View residential area. These data suggest that the plume is stable or shrinking, a fundamental premise toward the application of monitored natural attenuation. The highest DCA and benzene concentrations are

located just downgradient of the central PWIA. Additionally, quarterly monitoring conducted in 1999, and through June of 2000 show the trend continuing.

5.13.3 Redox Zonation

The biodegradation of petroleum hydrocarbons is a well documented process, and occurs at varying rates in almost all geochemical conditions. The biodegradation of petroleum fuels can be described by the redox reaction in which the hydrocarbon behaves as the electron donor (i.e., food source), and where oxygen is the primary electron acceptor under aerobic environments. When insufficient oxygen is available, or under anaerobic environments other chemicals such as NO_3^-, Mn^{+4}, Fe^{+3}, SO_4^{-2} , CO_2 can be used as alternate electron acceptors. These cations and anions are considered "low energy" electron acceptors.

Until the mid-1980s, chlorinated solvents were generally believed to be persistent in the subsurface environment until studies showed that microorganisms can transform chlorinated aliphatic compounds using a variety of mechanisms that depend on the properties of the chemical and the geochemical conditions of the aquifer (Bower and McCarty 1983, Vogel and McCarthy 1985). The most important of these mechanisms is reductive dechlorination.

Reductive dechlorination is a biochemical process that occurs under anaerobic conditions in which bacteria produce enzymes that remove chlorine atom(s) from its base carbon. Since this process leaves a hydrocarbon stripped of its chlorine, the molecule becomes susceptible to other natural degradation processes. In the redox reaction, the chlorinated VOC is the electron acceptor and molecular hydrogen is the typical electron donor.

In general, redox reactions proceed sequentially from the most thermodynamically favorable electron acceptor to the least favorable. Oxygen is the most favorable electron acceptor, followed sequentially by NO_3^-, Mn^{+4}, Fe^{+3}, SO_4^{-2} , CO_2 and chlorinated solvents. Because reductive dechlorination is a low energy yielding reaction, dechlorinating microorganisms will only compete with other bacteria using similar low energy electron acceptors. Accordingly, dissolved oxygen is toxic to the microbes in this process, and reductive dechlorination does not generally occur when the concentration of dissolved oxygen exceeds 1 mg/L (USEPA 1998). Reductive dechlorination may proceed along the following pathway:

TCA ! DCA ! chloroethane ! ethane (ethanol)

In general, three requirements are necessary to sustain the process of reductive dechlorination:

- the maintenance of reducing groundwater conditions,
- available electron donors and acceptors, and
- the presence of other nutrients required for cell growth.

Microorganisms are generally thought to be incapable of using tetra and tri-chlorinated organic compounds (i.e., PCA and TCA) as electron donors (food sources). However, once degraded by reductive dechlorination, more reduced chlorinated aliphatics (i.e., mono and di-chlorinated

compounds such as DCA) can be used as electron donors. In this case, microorganisms are able to degrade chlorinated VOCs in either an aerobic or anaerobic environment (Weidemeier et al. 1996).

Redox zonation is identified by monitoring terminal electron accepting processes and delineating particular "redox zones" in groundwater that are conducive to the degradation of various organic contaminants by measuring the concentration of electron acceptors (O_2, NO_3^-, Fe^{+3}, SO_4^{-2}, and CO_2) electron donors (TOC, BTEX, H_2S, H_2 and Fe^{+2}) , anions (nitrite, nitrate, chloride, sulfate, and bromide) and hydrogen gas (H_2) in groundwater. By measuring the concentration of various electron donors and acceptors and chemical by products in each groundwater sample, the site can be separated into different regions or zones that are characteristic of particular types of redox reactions. Delineating these "redox zones" is critical towards identifying what type of biodegradation is occurring on site. This information is summarized on Figure 5-27, and is discussed in this section.

- **Dissolved Oxygen:** As shown in Figure 5-27, the concentration of dissolved oxygen (DO) drops to near zero in the central PWIA, and levels out to around 1 mg/L in the Mountain View area. The consumption of DO in the central PWIA is due to the aerobic degradation (oxidation) of petroleum fuel. The depletion of DO in the central PWIA creates anaerobic environments in the central PWIA and provides proper conditions for the reductive dechlorination of chlorinated VOCs. Increases in DO along the base boundary are due primarily to the recharge events caused by surface water in this area and through the inflows from the reintroduction wells. Figure 5-27 depicts slight decreases in DO concentration along the Mountain View area, where groundwater is generally aerobic, and are associated with DCA and benzene biodegradation.

- **Sulfate:** As shown in Figure 5-27, the concentration of dissolved sulfate (SO_4^{-2}) decreases in the central PWIA. As shown in Figure 5-27, the concentration of dissolved sulfate (SO_4^{-2}) decreases in the central PWIA, where groundwater is anaerobic. The depletion Of SO_4^{-2} in the central PWIA is associated with benzene biodegradation coupled to sulfate reduction and indicates SO_4^{-2} is being utilized as a low energy electron acceptor.

- **Nitrate:** As with sulfate, the concentration of nitrate (NO_3^-) decreases in the central PWIA indicating that reducing conditions are present and that NO_3^- is being used as a low energy electron acceptor.

- **Iron:** In the absence of oxygen, ferric iron (Fe^{+3}) can be used as an electron acceptor in redox reactions. However, because Fe^{+3} usually occurs in the solid state and tends to sorb onto aquifer materials, it is more convenient to measure the concentration of dissolved ferrous iron (Fe^{+2}), the reduced state of iron. In iron reducing conditions ferrous iron will be more abundant and detected concentrations should increase over background levels. As shown in Figure 5-27, the concentration of Fe^{+2} ranges from near zero upgradient of the PWIA, to greater than 5 mg/L within the central PWIA indicating that iron reducing conditions are present.

- **Hydrogen:** Dissolved molecular hydrogen is the electron donor that drives reductive dechlorination, and is a direct indicator of the redox conditions. High concentrations of hydrogen (greater than 1 nM/L) are associated with the highly reductive core of the plume in the central PWIA (8MW53, 28MW01, and MW05). As shown in Figure 5-27, dissolved hydrogen increases in the central PWIA and indicates iron-reducing conditions in this area.

- **Carbon Dioxide:** When other alternate or low energy electron acceptors have been reduced, the lowest energy molecule CO_2 is then reduced and generates methane (CH_4) as by product of CO_2 reduction. As shown in Figure 5-27, the concentration of CO_2 drops sharply in the central PWIA indicating that it is being depleted as a low energy electron acceptor during reductive dechlorination.

- **Methane:** Methane is a by-product from the reduction of CO_2. As shown in Figure 5-27, high concentration of methane gas in the central PWIA indicates highly reducing conditions in that area. Methanogenic conditions are optimal for the reductive dechlorination of chlorinated VOCs.

With respect to the concentration of various electron donors and acceptors in OU 8 groundwater, the following conclusions can be drawn:

- The central portion of the PWIA is characterized by highly reducing groundwater conditions which are ideal for reductive dechlorination of chlorinated VOCs.

- There appears to be an ample supply of electron donors (hydrogen and petroleum hydrocarbon) and electron acceptors (NO_3^-, Mn^{+4}, Fe^{+3}, SO_4^{-2}, CO_2) to sustain of reductive dechlorination process.

- Aerobic groundwater conditions downgradient from the PWIA are amendable to the biodegradation of both petroleum compounds and reduced dichlorinated VOCs (i.e., DCA).

5.13.4 Nutrients and Food Sources

As noted in the section above, favorable conditions exist and there appears to be an ample supply of electron donors (food sources) and acceptors to sustain the metabolic activity of dechlorinating microbes, and as long as relatively high concentrations of BTEX persist in the immediate vicinity of the gas station, reducing groundwater conditions will be present.

Other than water, the three crucial nutrients necessary for sustaining microbial growth and activity are carbon (C), nitrogen (N), and phosphorous (P). While a C:N ratio of 20 and a C:P ratio of 100 are considered optimal, the critical factor controlling cell growth is the presence (or absence) of these nutrients (Benefield 1985). At OU 8, the shallow Qva aquifer has an average C:N and C:P ratio of 8.25 and 199.5, respectively (EA 1999b). These data indicate that the availability of nutrients is not a limiting factor for microbial growth.

5.13.5 Daughter Product Analysis

Six chlorinated VOCs (DCA; 1,1,2-TCA; trichloroethene; DCE; 1,2-dichloropropane; and carbon tetrachloride) were detected in groundwater at OU 8. DCA was the most commonly detected chlorinated VOC. DCA was detected in 46 wells, 1,1,2-trichloropropane was detected in 22 wells, 1,1,2-TCA and trichloroethene were detected in 18 wells, DCE was detected in 17 wells, and carbon tetrachloride was detected in 9 wells throughout OU 8. Although the nature of the chlorinated solvent release(s) in the PWIA is not know, based on the industrial practices at OU 8, it is reasonable to assume that an isomer of TCA was the principle release chemical. Evidence supporting this conclusion includes:

- trichlorinated solvents were common degreasers used in the de-militarizing of weapons and vehicle servicing that were the dominant activities of SUBASE Bangor,
- trichlorinated solvents are more versatile in their general industrial application, and
- DCA is typically detected just downgradient from the reducing environments in the central PWIA where elevated TCA concentrations were detected.

DCA is the primary product of reductive dechlorination of TCA. The presence of daughter products and the ratios of parent to daughter were compared to evaluate reductive dechlorination of TCA at OU 8. Figure 5-28 shows the TCA:DCA ratios for the shallow wells in the on-base portion of OU 8. For the purposes of this daughter product evaluation, the base is divided into three separate regions: upgradient, the central PWIA, and the base boundary.

The ratio of TCA:DCA equal to or greater than one indicates that TCA is still available for reductive dechlorination. TCA:DCA ratio of less than one indicates that DCA is the dominant compound in groundwater. As shown in Figure 5-28, TCA:DCA ratios are above one in the upgradient area of OU 8. The ratios drop sharply in the highly reduced zone of the central PWIA, where reductive dechlorination of TCA occurs. The ratios slightly increase in the base boundary area downgradient of the central PWIA.

Among the final degradation daughter products of chlorinated VOCs are ethene and ethane, but they are difficult to detect due to their tendency to readily volatilize dissipate within a well casing rather than stay in solution. However, ethene was detected in three monitoring wells within the PWIA (8MW24, 8MW48 and MW05) at concentrations of 0.02 mg/L. Vinyl chloride, an intermediate degradation product of chlorinated VOCs, has been rarely detected in OU 8 groundwater. This is because vinyl chloride is generally produced and persists in highly reducing environments where there is little or no subsequent mixing of oxygenated groundwater.

5.13.6 Contaminant Transport Model

A contaminant transport model was prepared as part of the RI to evaluate the processes of natural attenuation on the predicted benzene and DCA concentrations in OU 8 groundwater. The model

was constructed using both the groundwater flow computer program (MODFLOW) and the groundwater solute transport computer program (MT3D). MT3D is used to simulate the changes in concentration of a single dissolved contaminant through time. It is specifically designed to interface with MODFLOW to create a three-dimensional groundwater flow and transport model. The contaminant transport model was executed using the processing software package GMS (version 2.1). The current contaminant transport model version IV was executed under both pumping and non-pumping scenarios. A secondary source for benzene was included in Version IV of the model to account for the mass of benzene partitioning to groundwater from LNAPL. Additionally, a secondary source term for DCA was modeled to account for the consistent concentration of DCA in groundwater in the central PWIA. Predictive simulations were executed for times 5, 10, 15, and 20 years into the future (year 2002, 2007, 2012, and 2017). The input parameters for the MT3D groundwater model are summarized in Table 5-11.

Table 5-11. MT3D Groundwater Model Input Parameters.

Parameter	Units	Layer 1	Layer 2	Layer 3	Layer 4	Layer 5
Effective Porosity (n_e)[1]	%	10	10	1	0.1	1
Hydraulic Conductivity (K)[1]	Ft/day	4 zones[6]	5 zones[7]	0.55	0.0053	0.55
Specific Yield / Storativity (S)[2]	%	10	0.001	0.00016	0.00001	0.0001
Longitudinal Dispersivity (D_L)[3]	ft	50	50	5	1	5
Transverse Dispersivity (D_T)[3]	ft	0.1–D_L	0.1–D_L	0.1–D_L	0.1–D_L	0.1–D_L
Vertical Dispersivity (D_V)[3]	ft	0.01–D_L	0.01–D_L	0.01–D_L	0.01–D_L	0.01–D_L
DCA K_{oc}[4]	ft^3/lb	0.38	0.38	0.38	0.38	0.38
Benzene K_{oc}[4]	ft^3/lb	0.987	0.987	0.987	0.987	0.987
Organic Carbon (f_{OC})[1]	%	0.9	0.9	0.51	0.51	0.51
DCA K_d[5]	ft^3/lb	0.0034	0.0034	0.019	0.019	0.019
Benzene K_d[5]	ft^3/lb	0.0088	0.0088	0.005	0.005	0.005
Soil Bulk Density[1]	lbs/ft^3	120	120	125	125	125
DCA 1st Order Decay[8]	1/day	0.0025	0.0025	0.002	0.002	0.002
Benzene 1st Order Decay[8]	1/day	0.0038	0.0038	0.002	0.002	0.002

1 Value(s) obtained from Foster Wheeler (1996b, 1998a) and/or this OU 8 Remedial Investigation.

2 Estimated values obtained from Fetter (1988), and Domenico and Schwartz (1990).

3 Value obtained from Tennessee Valley Authority (1985) and/or Zheng (1995).

4 Value obtained from Mackay, Shiu, and Ma (1992).

5 $K_d = K_{OC\emptyset}\, f_{OC}$

6 Layer 1 contains 5 zones of hydraulic conductivity decreasing towards the southeast: 50, 46, 11, 6, and 1.2 ft/day.

7 Layer 2 contains 6 zones of hydraulic conductivity decreasing towards the southeast: 50, 46, 23, 19, 10, 1.2 ft/day.

8 First order decay rate (k) is input to MT3D using the following equation: $k = 0.693/t^2$, or $k=-1n(C_C/C_C)/t^2$, where t^2=chemical half-life, and C_C/C_C=ratio of half-life concentration to initial concentration.

Additional Notes:

S Published values of decay rates and distribution coeffcients may vary over a large range. The values selected represent

Conservative estimates in the range.

S Units of time mass, and length for MT3D input are days, pounds, and feet; respectively.

The selection of distribution coefficients (K_d) and decay rates (k) for input to the model was based upon published references including Mackay, Shiu and Ma (1992); Weiderneir et al. (1996); Howard (1989); and USEPA (1989). These references typically provide values, or ranges of values for the organic carbon partition coefficient (K_{oc}) for various chemicals including DCA and benzene. The actual K_{oc} value selected for input to the model 61.6 ml/g for benzene and 23.7 ml/g for DCA) represents the average of numerous values obtained from different studies as reported by Mackay, Shiu and Ma (1992). Similarly, decay rates for DCA and benzene were calculated from published values of half-life in groundwater using the following equation:

$$k = 0.693/t^{1/2}$$

The actual half-life selected (182 days for benzene and 279 days for DCA) was towards the upper (higher or more conservative) end of the values reported by Mackay, Shiu and Ma (1992).

Results from the model indicate that without implementing any active groundwater cleanup technology or source control technology the predicted future concentrations of benzene and DCA in the off-base portion of the Qva aquifer will be below 5 Fg/L in 10 years through natural attenuation. There is little difference in predicted future concentrations or extent of benzene and DCA under pumping versus non-pumping scenarios.

The mass balance of benzene and DCA in the transport model can be used to qualitatively illustrate the removal efficiency of the P&T system and natural attenuation processes. Based on the results from the model, the primary mechanism for benzene and DCA removal is through biodegradation. Groundwater extraction wells, when active, account for approximately 25 percent of the DCA mass and approximately 2 to 5 percent of the benzene mass that are removed through biodegradation.

The MT3D model was run using benzene and DCA concentrations from groundwater samples collected from monitoring wells at OU 8. These data were used because benzene and DCA are spatially distributed throughout the impacted groundwater and they define the extent of the plume. The other COCs were not incorporated into the model because they were not detected throughout the plume. These VOCs (EDB, dichloropropane, and toluene) have similar properties to benzene and DCA and are also biodegradable. DCA is the most recalcitrant constituent and therefore its decay rate is the time-limiting factor for remediation.

6.0 CURRENT AND POTENTIAL FUTURE SITE AND RESOURCE USES

This section discusses the current and reasonable anticipated future land uses and current and potential beneficial groundwater uses at OU 8.

6.1 LAND USES

The OU 8 groundwater extends throughout the PWIA and on privately owned, off-base parcels of property that are residential. The PWIA is primarily used as an industrial area by the Navy. SUBASE Bangor's military mission is considered critical to national security; it is therefore intended to remain a military base indefinitely. Therefore it is anticipated that the PWIA will remain in this use for the long-term foreseeable future. Adjacent land uses are primarily residential uses.

6.2 GROUNDWATER USES

Several private wells at individual residences have been identified as being completed within the Shallow Aquifer both within and downgradient of OU 8 (Figure 5-13). Institutional controls have been implemented to ensure that none of the private wells within OU 8 are used for drinking water, although some private wells may be used for irrigation. The residents within or around OU 8 are currently connected to the municipal water supply system. Because the public water supply is readily accessible, all new residential developments will also be connected to the municipal water supply, unless the Public Health District approves the use of well water.

The primary future beneficial use of the Shallow Aquifer of OU 8 is for domestic water supply. Current groundwater use restrictions by the Kitsap County Public Health District prohibit the use of existing wells for household purposes.

7. SUMMARY OF SITE RISKS

The baseline risk assessment estimates risks posed by OU 8 if no action were taken. It provides the basis for taking action and identifies the contaminants and exposure pathways that need to be addressed by remedial action. This section summarizes the results of the baseline risk assessment for OU 8. Human health risk assessments (HHRAs) and an ecological risk assessment were performed at OU 8 as part of the RI.

Two human health risk assessments were performed for OU 8. The original risk assessment was performed using soil and groundwater data collected during the remedial investigation between January 1995 and August 1996. This assessment is referred to as the 1995/96 risk assessment. The 1995/96 risk assessment assumed that receptors had unrestricted uses of groundwater. Unacceptable cancer risks were estimated for future on-base residents, current off-base residents, and future off-base residents associated with exposure to groundwater. Human health risks from exposure to surface and subsurface soils were within the EPA and MTCA acceptable ranges. Exposures to soil at the site pose no unacceptable risks to human receptors.

During the feasibility study, the risk evaluations were updated using 1998 and 1999 groundwater data collected during the on-going groundwater monitoring program. The updated risk evaluation is referred to as the 1998/99 risk assessment. It focuses on evaluating risks to future off-base receptors through groundwater pathway and assumed that future off-base receptors had unrestricted uses of groundwater. Unacceptable cancer risks were estimated for future off-base residents.

No contaminants of potential ecological concern exceeded risk-based screening concentrations for any medium. Therefore, ecological risks were not predicted.

The response action selected in this ROD is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment. Such a release, or threat of release, may present an imminent and substantial endangerment to public health, welfare or the environment.

7.1 HUMAN HEALTH RISK ASSESSMENT

The baseline risk assessment evaluated potential effects on human health posed by exposure to contaminants within OU 8. The baseline risk assessment was conducted in accordance with EPA guidance and default assumptions, and was designed to provide a comprehensive assessment summarizing all quantitative soil and groundwater risk estimates and associated COCs at OU 8. The baseline risk assessment for OU 8 focused on health effects for both children and adults who might drink contaminated groundwater used as a domestic water supply and on health effects to adult workers who might accidentally ingest contaminated soil. Because of the previous groundwater removal efforts to provide municipal water supply connections to residents in the immediate vicinity of the groundwater plume, no one is currently being exposed to contaminated groundwater at levels above health concerns.

The following four separate steps in the risk assessment process were conducted for each of the two assessments:

- Evaluation of data and identification of COPCs,
- Identification and quantification of COPC toxicity,
- Identification of exposure pathways and potential human receptors, and
- Characterization of potential human health risks to current and future receptors.

7.1.2 Data Evaluation and Identification of COPCs

Appendix B presents the exposure point concentration for each of the COPCs detected in soil and groundwater during the 1995/96 human health risk assessment and how it was derived. The exposure point concentration is the concentration that is used in the calculations to estimate the exposure and risk from each COPC in soil and/or groundwater.

The 1995/96 human health risk assessment identified nine COPCs in off-base groundwater, 29 COPCs in on-base groundwater, and seven COPCs in on-base subsurface soil. The 1998/99 risk assessment identified 12 COPCs in off-base groundwater. These COPCs were carried through the risk assessment process. COPCs that presented an unacceptable risk to human health were then identified as COCs. Table 5-8 lists the COCs from the 1995/96 and 1998/99 human health risk assessments and the potential chemical-specific ARARs.

7.1.3 Toxicity Assessment

Toxicity assessment is the process of characterizing the relationShiu between the dose of a chemical and the anticipated incidence of an adverse health effect. A toxicity assessment presents available toxicity goals developed by EPA for evaluation of the potential risks from exposure to toxic chemicals. The toxicity information was obtained from the Integrated Risk Information System (IRIS), Health Effects Assessment Summary Tables (HEAST), and provisional values provided by the Superfund Technical Support Center.

For risk assessment purposes, chemical effects are separated into two categories of toxicity: noncarcinogenic effects and carcinogenic effects. Cancer and noncancer toxicity data for the oral/dermal and inhalation pathways in soil and groundwater are not summarized here, but are presented in the baseline risk assessment contained in the RI and FS reports. Tables 7-1 and 7-2 summarizes the noncancer and cancer toxicity data for COCs identified in the 1995/96 and 1998/99 risk assessments.

7.1.4 Exposure Assessment

An exposure assessment was conducted to identify exposure pathways and potential receptors, and quantify exposure pathways at OU 8. Future land use for the PWIA will most likely be similar to current conditions. Construction workers and on-base residents are the most likely potential future receptors who could be exposed to on-base contaminants in soil and groundwater. Future uses of the Mountain View neighborhood could differ considerably from

current residential uses. To be protective of human health and the environment, it was conservatively assumed for the human health risk assessments that the future land uses of the Mountain View neighborhood remain residential. Table 7-3 summarizes potentially complete exposure pathways identified for potential receptors at OU 8. These pathways are depicted in the site conceptual model shown in Figure 5-25. The 1998/99 risk assessment only considered the exposure pathway for future off-base residents.

7.1.5 Risk Characterization

Risk characterization is defined as the nature and magnitude of potential human health risks including their inherent uncertainty. For carcinogens, risks are generally expressed as the incremental probability of an individual's developing cancer over a lifetime as a result of exposure to the carcinogen. Excess lifetime cancer risk is calculated from the following equation:

$$Risk = CDI \times SF$$

where:

risk	'	a unitless probability (e.g., $2x10^{-5}$ or 2 in 100,000) of an individual's developing cancer
CDI	'	chronic daily intake averaged over 70 years (mg/kg-day)
SF	'	carcinogenic slope factor, expressed as $(mg/kg\text{-}day)^{-1}$

The risks are probabilities that usually are expressed in scientific notation (e.g., 1×10^{-5} or 1 in 100,000). An excess lifetime cancer risk of $1x10^{-6}$ or 1 in 1,000,000 indicates that an individual experiencing the reasonable maximum exposure estimate has a 1 in 1,000,000 chance of developing cancer as a result of site-related exposure. This is referred to as an "excess lifetime cancer risk" because it would be in addition to the risks of cancer individuals face from other causes such as smoking, or exposure to too much sun. The chance of an individuals' developing cancer from all other causes has been estimated to be as high as one in three. EPA's generally acceptable risk range for site-related exposures is $1x10^{-4}$ to $1 x10^{-6}$ (1 in 10,000 to 1 in 1,000,000). Based on the MTCA, for sites involving multiple chemicals and multiple pathways of exposure, the total excess lifetime cancer risk shall not exceed $1x10^{-5}$ (1 in 100,000).

Noncarcinogenic health effects are evaluated by comparing an exposure level over a specified time period (e.g., life-time) with a reference dose (RfD) derived for a similar exposure period. An RfD represents a level that an individual may be exposed to that is not expected to cause any deleterious effect. The ratio of exposure to toxicity is called a hazard quotient (HQ). An HQ of less than one indicates that a receptor's dose of a single contaminant is less than the RfD, and that toxic noncarcinogenic effects from that chemical are unlikely. The Hazard Index (HI) is generated by adding the HQs for all chemical(s) of concern that affect the same target organ (e.g., liver) or that act through the same mechanism of action within a medium or across all media to which a given individual may reasonably be exposed. An HI of less than one indicates that, based on the sum of all HQs from different contaminants and exposure routes, toxic

noncarcinogenic effects from all contaminants are unlikely. An HI of greater than one indicates that site-related exposures may present a risk to human health.

The HQ is calculated as follows:

$$HQ = CDI/RfD$$

where:

CDI ' Chronic daily intake
RfD ' reference dose

CDI and RfD are expressed in the same units and represent the same exposure period (i.e., chronic, subchronic, or short-term).

Sites posing a cumulative lifetime excess cancer risk of $l \times l0^{-4}$ (1 in 10,000) or less may not pose an unacceptable cancer risk and may not require remedial activities. Under most situations, cancer risks in the range of $1x10^{-4}$ to $1x10^{-6}$ and non-cancer hazard indices of one or less are considered to be acceptable. The EPA's Risk Assessment Guidance for Superfund (RAGs) states that a HI greater than one indicates the potential for adverse non-cancer effects. Based on the MTCA for sites involving multiple chemicals and multiple pathways of exposure, the total excess lifetime cancer risk shall not exceed $1x10^{-5}$ (1 in 100,000) and the HI shall not exceed one. Under the State of Washington regulations, risks above this range are generally considered unacceptable, in which case remediation may be required.

7.1.6 1995/96 Human Health Risk Assessment Conclusions

Tables within Appendix B provide a summary of the COPC selection process and statistics that serve as the basis for risk estimates for all exposure pathways. The risk estimates are based on a reasonable maximum exposure following EPA guidance and standard default assumptions.

Future On-Base Construction Workers
Unacceptable cancer risks or adverse health effects other than cancer were not identified for future on-base construction workers. There are no unacceptable cancer risks associated with exposure to soil at the site for future on-base construction workers.

Future On-Base Residents
For a future on-base resident using contaminated groundwater from the Shallow Aquifer as a primary water source, significant risk would be anticipated from ingestion of chemicals in groundwater. The excess lifetime cancer risk to future on-base child and adult residents is $2x10^{-2}$. The majority of excess cancer risk is attributed to concentrations of benzene, EDB, and DCA in groundwater. The HIs for future on-base child and adult residents are 92 and 53, respectively. The COC contributing most to the total HI is benzene, which has both cancer risk and adverse health effects.

Current Off-Base Residents
The excess lifetime cancer risk for current off-base child and adult residents are $3x10^{-4}$ and $7x10^{-4}$, respectively. The majority of this excess cancer risk is attributed to concentrations of bis(2-ethylhexyl)phthalate and benzene in groundwater. Ingestion of livestock fed on crops irrigated with contaminated groundwater was the exposure pathway contributing most to the estimated cancer risks. Other completed exposure pathways include inhalation of fugitive dusts and or particulates from surface soil irrigated with potentially contaminated groundwater and inhalation of vocatives from groundwater during irrigation. The his for current off-base child and adult residents are 5 and 6.5, respectively. The COC contributing most to the HIs is bis(2-ethylhexyl)phthalate.

Future Off-Base Residents
The excess lifetime cancer risk for future off-base child and adult residents are $4x10^{-4}$ and $1x10^{-3}$, respectively. The majority of excess cancer risk is attributed to concentrations of benzene, and bis(2-ethylhexyl)phthalate in groundwater. Ingestion of groundwater, ingestion of crops irrigated with groundwater, and ingestion of livestock fed on crops irrigated with contaminated groundwater were the exposure pathways contributing most to the estimated cancer risks. The total HIS for future off-base child and adult residents are 5.6 and 6.5, respectively. The COCs contributing most to the total HIS are benzene and bis(2-ethylhexyl)phthalate.

7.1.7 1998/99 Human Health Risk Assessment Conclusions

The 1998/99 risk assessment re-considered potential human health risks to the **future off-base** residents using a reasonable maximum exposure following EPA guidance and standard default assumptions. The excess lifetime cancer risk for future off-base child and adult residents are $3x10^{-4}$ and $4x10^{-4}$, respectively. The majority of excess cancer risk is attributed to concentrations of bis(2-chloroethyl) ether in groundwater. Ingestion of groundwater was the exposure pathway contributing most to the estimated cancer risks. The HIs for future off-base child and adult residents are 0.33 and 0.36, respectively.

Tables within Appendix C provide a summary of the COPC selection process and statistics that served as the basis for the risk estimates for all exposure pathways. The risk estimates are based on a reasonable maximum exposure and were developed by taking into account various conservative assumptions about the frequency and duration of exposure to soil and groundwater, as well as the toxicity of the COPCs.

7.1.8 Uncertainties and Limitations in Estimating Health Risks

Uncertainties associated with the risk assessment include:

- Sampling and analytical methods,
- Sample location and number of samples,
- Assumption that chemical concentrations remain constant over time,
- Use of conservative assumptions with regard to exposure parameters and toxicity values,

- Use of fate and transport modeling to estimate chemical concentrations in other media, and ,
- The assumption of additive risk for similar toxicological effects.

During the 1998/99 risk assessment, SVOCs were analyzed in groundwater samples collected from wells located at the base boundary and off-base. A single detection of SVOC was identified from a well located at the base boundary. The infrequent detection and the nature of the SVOC detected results in uncertainty in the risk estimations. The nature and extent of SVOC do not indicate any relation to the Navy's activities and do not appear to correlate to a specific contaminant plume or source.

To evaluate the pathway associated with groundwater under future site conditions, the concentrations present in groundwater were used to represent exposure point concentrations throughout the duration of exposure. No changes in concentrations as a result of natural attenuation or treatment processes were considered. Impacted groundwater in its present state is unlikely to be used as a potable water source unless groundwater conditions improve. Consequently, the estimated carcinogenic risks and non-carcinogenic health effects from ingestion of chemicals in groundwater may be overestimated.

Although there are uncertainties associated with the human health risk assessment, it is expected that the risks presented are conservative and actual risks may be lower than those estimated in this assessment.

7.2 ECOLOGICAL RISK ASSESSMENT

The ecological risk assessment evaluates the likelihood that adverse ecological effects may occur or are occurring as a result of exposure to one or more releases at the site. The objective of the ecological risk assessment was to estimate potential impacts to ecological receptors at the site. The estimate of potential impacts was based on sampling and analyses conducted during the remedial investigations.

A Tier I screening level ecological risk assessment was performed as part of the OU 8 RI. The risk assessment presents a comparison of contaminant concentrations in off-base surface seep water, seep sediment, ponded irrigation water, and irrigated soil to chemical-specific risk-based screening concentrations. Maximum detected chemical concentrations were used as exposure point concentrations in seep water and sediment. Analytes detected in groundwater were used in an irrigation model to calculate the maximum concentrations of contaminants in ponded irrigation water and irrigated soil. Surface water and sediment risk-based screening concentrations were chosen for aquatic and sediment-dwelling species (i.e., fish, invertebrates, and plants) from available literature, while soil and drinking water risk-based screening concentrations for wildlife functional groups (small mammals, song/perching birds, waterfowl, raptors) were derived using conservative allometric exposure models. Measured and modeled exposure point concentrations were then compared to the risk-based screening concentrations for each media.

The contaminated groundwater of OU 8 Shallow Aquifer does not discharge to surface water. Groundwater seep and sediment samples were collected from three locations along Clear Creek (Section 5.9.3), and no VOCs or SVOCs were detected at concentrations exceeding the MTCA Method B or the RBSCs. Because there are no contaminants of potential ecological concern which exceeded RBSCs for both seep and sediment samples, ecological risks were not predicted.

8. REMEDIAL ACTION OBJECTIVES

Remedial action objectives (RAOs) provide a general description of what the cleanup action will accomplish. RAOs were developed based on findings of the risk assessment by taking into consideration overall risk management objectives. Specific RAOs developed for OU 8 are focused on addressing unacceptable human health risks posed by exposure to the identified COCs, exposure pathways, and environmental media. These RAOs set goals to be accomplished by remedial actions. This ROD does not present specific RAOs for soil cleanup, because soil presents no risk to human health and will be addressed through the groundwater cleanup goals. RADS developed for OF 8 and how they can be achieved are summarized below.

RAO	How Selected Remedy Achieves RAO
C Minimize the migration of VOCs from LNAPL beneath the PWIA into groundwater at concentrations that would cause adverse non-cancer risks.	C Free- Product Recovery (FPR)–physically removes LNAPL beneath the PWIA. C Removal of LNAPL will reduce an ongoing source for groundwater contamination and reduce the source of residual soil contamination. After the LNAPL has been removed as much as practicable, natural attenuation and biodegradation may reduce the residual contamination in soil.
C Minimize human exposure to COCs in site-wide groundwater that would result in adverse non-cancer health effects or unacceptable cancer risks.	C Institutional Controls (ICs) (off base) – prohibit the use of groundwater until MCLs are reached and provide an alternate water supply. C ICs (on base) – SUBASE Bangor Institutional Control Management Plan (ICMP) prohibit the use of groundwater and installation of groundwater wells in OU 8 Shallow Aquifer. C MNA – destruction of contaminants in site-wide groundwater.

In selecting a cleanup level, the Navy considered the future on-base and off-base land use, the risks to human health, and the applicable MTCA regulation (WAC 173-340-720[3][a][ii][B]). The Navy primarily uses the PWIA as an industrial area. SUBASE Bangor's military mission is considered critical to national security; it is therefore intended to remain a military base indefinitely. Therefore, it is anticipated that the PWIA will remain in this use for the long-term foreseeable future. Off-base adjacent land uses are primarily residential and are expected to remain residential.

On the basis of the baseline risk assessment, risks from COCs in groundwater were identified at levels that exceed the EPA risk threshold and may, therefore, pose a potential threat to human health. The NCP requires that excess lifetime cancer risk at a site not exceed the range of $1x10^{-6}$ to $1x10^{-4}$. The State of Washington MTCA is more stringent and requires that this excess lifetime cancer risk not exceed $1x10^{-5}$.

Based on the risk assessments, unacceptable human health risks exceeding the EPA and MTCA ranges were identified for exposure to contaminated groundwater at OU 8. Human health risks from exposure to surface and subsurface soils were within the EPA and MTCA acceptable range. There are no unacceptable risks to human receptors from exposure to COCs in soil at the site.

The 1995/96 risk assessment identified the occurrence of SVOCs at concentrations that could result in unacceptable cancer risks or adverse health effects upon bioaccumulation into the human food chain. During the 1998/99 risk assessment, SVOCs were analyzed in groundwater samples collected from wells located at the base boundary and off base. A single detection of SVOC was identified in the well located at the base boundary. The infrequent detection and the nature of the SVOC detected results in uncertainty in the risk estimations. The nature and extent of SVOC do not indicate any relation to the Navy's activities and do not appear to correlate to a specific contaminant plume or source. Therefore, there are no RAOs developed to address SVOC in groundwater.

8.1 SOIL

Petroleum contaminated soil beneath the PWIA service station was identified as a media of concern for human health risks solely due to its impact on groundwater. The Navy has successfully addressed the contaminated soil from surface to a depth of 15 feet bgs under the SUBASE Bangor UST program.

In December 1999, confirmatory soil samples were collected beneath the PWIA service station to a depth of 15 feet bgs. The results indicated that the soil has been remediated to meet Ecology's cleanup standards. **In February 2000, Ecology notified SUBASE Bangor that no further action is necessary to cleanup the soil beneath the PWIA service station to a depth of 15 feet bgs.**

There are no human health risks related to exposure to contaminated soil beneath the PWIA service station. In addition, a soil removal action to address contamination at these depths within the confines of a heavily developed PWIA would be extremely difficult, costly, and would not significantly minimize further groundwater contamination. The LNAPL found at the site presents an ongoing source of contamination to groundwater and residual soil from 15 feet bgs to groundwater. The installation and operation of a free-product recovery system would reduce the ongoing source of groundwater contamination on base and off base and would reduce the source of residual soil contamination on site. After the LNAPL has been removed to the extent practicable, the groundwater cleanup remedy will remain in place until the groundwater meets cleanup goals, at which time the residual soil contamination will no longer represent a source or

pose a threat to groundwater quality. Accordingly, there are no RAOs for residual contaminants in soil.

8.2 GROUNDWATER

For OU 8, the chemical-specific cleanup levels for groundwater are shown in Table 8-1 and were determined as specified in MTCA Cleanup Regulations [WAC 173-340-720 (3) (a) (ii) (B)]. Specifically, the cleanup levels for the remedial action at OU 8 are: benzene, 5 Fg/l; 1,2-dichloroethane (1,2-DCA), 5 Fg/l;1; dibromoethane (EDB), 0.000515 Fg/l; 1,1-dichloroethene (1,1 -DCE), 0.0729 Fg/l; and toluene, 1000 Fg/l. Because the cleanup levels for EDB and 1,1- DCE are below concentrations normally measurable in lab analysis at the time of this ROD, evaluation of the remedial action's compliance with the cleanup levels for EDB and 1,1-DCE will be based upon the practical quantitation limit. Compliance with the cleanup levels for each of the chemicals listed above will be attained in groundwater throughout OU 8.

Cleanup goals have been established for the primary COCs and other COCs that have been detected at concentrations exceeding the cleanup criteria as determined by groundwater data evaluated for the 1995/1996 and 1998/99 risk assessments (Table 8-1). The cleanup goal for OU 8 groundwater is to achieve the federal drinking water maximum contaminant level (MCL) where the MCL results in risks that do not exceed the MTCA risk standards of $1x10^{-5}$ cancer risk and the hazard quotient (HQ) of 1.0 when calculated using the MTCA Method B equation [WAC 173-340-720 (3) (a) (ii) (B)].

Off-Base Groundwater

Given that the primary future beneficial use of OU 8 Shallow Aquifer is for domestic water supply and that the future land use of the off-base portion of OU 8 will remain residential, the Navy established an initial cleanup goal for off-base groundwater. The initial cleanup goal is to apply the MNA remedy to achieve the drinking water standards (MCLs) in the off-base portion of OU 8 within a ten year period (modeling data) or 2008. The Navy will use existing monitoring wells located at the base boundary and off base to evaluate the progress of the selected remedy in achieving the initial cleanup goal. Off-base institutional controls will be implemented until the contaminant concentrations in the off-base groundwater are below the drinking water standards (MCLs). However, groundwater monitoring of COCs for compliance with cleanup standards will be continued until the cleanup standards are met.

On-Base Groundwater

In the human health risk assessment, the Navy considered future on-base residents and construction workers as potential receptors of concern on base. The future resident receptor scenario is conservative in terms of protection to human health, because the current and future land use for the site is industrial. The exposure pathways for these receptors included ingestion of, and dermal contact with contaminated groundwater during irrigation of soils; ingestion of plants (i.e., consumable vegetation crops) irrigated with contaminated groundwater and ingestion of animal tissue that could consume vegetation and ingest soils irrigated with contaminated

groundwater. The results of the human health risk assessment indicated that on-base groundwater containing benzene, bis(2-ethylhexyl)phthalate, toluene, EDB, DCE, and DCA poses a potential health risk to future residents. The cleanup goal for on-base groundwater is to achieve the cleanup standards shown in Table 8-1 which are based upon the MTCA Method B equation [WAC 173-340-720 (3) (a) (ii) (B)]. Table D-1, presented in Appendix D, shows the how these cleanup standards were derived. Groundwater samples from selected on-base monitoring wells will be evaluated to determine the progress of the selected remedy. ICs implemented on base include prohibition of installing drinking water wells within the entire OU 8 site. On-base institutional controls will be implemented until the contaminant concentrations in the on-base groundwater are below the MCLs.

8.3 PETROLEUM SOURCE CONTROL

The LNAPL presents an ongoing source of contamination to groundwater and residual soil. Removal of LNAPL to the extent practicable will address the principal threat and minimize the migration of VOCs to groundwater. The practicable endpoint for removal of LNAPL will be defined on a monthly average recovery over a one-year period. The Navy has proposed a quantity of 0.5 gallons per month, cumulative from all wells connected to the recovery system, over a one-year period as the practicable endpoint. If the recovery rate decreases to the practicable endpoint, post recovery monitoring will be initiated to gauge the residual product thickness in recovery wells and monitor adjacent wells for product. The status of the groundwater cleanup goals will be evaluated within the 5-year review process.

8.4 INSTITUTIONAL CONTROLS

ICs have been implemented to prevent current and future off-base residents and future on-base residents from exposure to groundwater beneath the site by preventing the use and consumption of groundwater.

The Navy implemented ICs as part of the voluntary time-critical removal action in 1995. Off-base ICs consist of negotiated water use agreements with private land owners. These agreements prohibit installation of water supply wells and prohibit household use of groundwater in the Mountain View neighborhood. As part of the 1995 time critical removal action, the Navy connected the Mountain View residents in the impacted area to a municipal water supply to prevent exposure.

On-base ICs include prohibitions on installing water supply wells within the Shallow Aquifer beneath and subjacent to the OU 8 boundary area, protection of existing monitoring wells, and ensuring the integrity of all remedy components. Deed restrictions will apply to the land in the event of property transfer to a non-federal entity. These controls will be implemented by an Institutional Control Management Plan (ICMP).

The ICMP will identify all areas subject to the institutional controls selected in the ROD; identify the objectives of the ICs; specify the anticipated time frames that ICs are to remain in effect, identify inconsistencies with the ICs objectives or protectiveness criteria and establish a

procedure to avoid/prevent such activities. The Navy will prepare an annual monitoring report that includes information such as current land users and uses, field inspection, records review and process review of monitoring the ICs. The annual monitoring report will provide a description of how facility wide requirements are met, including a checklist identifying results of field inspections, and documentation of any failures. The monitoring report will also identify if ICs are being met, and will describe any deficiencies that affect the protectiveness of the remedy and efforts taken, if any, to correct these deficiencies.

Institutional control will be administered by the federal government while it owns the property. In the event of transfer of the property, it will be necessary to include deed or land use restrictions to implement the institutional controls. Deed restrictions cannot be placed on the property until transfer of the property. Upon transfer of the property, notification of the history of the site will be attached to any property transfer, which would have to meet the requirements of CERCLA Section 120(h).

The Navy is seeking General Services Administration (GSA) approval of deed restrictions that will be included in the conveyance document to effectuate the ROD in the event of transfer of the property to a non-federal entity. Such deed restrictions will address any limits to remain in effect after the time of transfer to restrict land use, restrict the use of groundwater, and manage excavation. The deed covenants will also include provisions addressing the continued operation, maintenance, and monitoring of the selected remedy.

9. DESCRIPTION OF ALTERNATIVES

This section provides a brief description of the alternatives developed for OU 8. The Navy identified and evaluated various groundwater cleanup technologies based on their ability to control the contaminant source, to remove contaminants from groundwater, and to prevent human exposure to contaminated groundwater. Technologies that are effective and implementable were retained for inclusion in cleanup alternatives. The retained cleanup technologies are:

- Institutional controls (ICs)
- Long term monitoring (LTM)
- Monitored natural attenuation (MNA)
- Soil vapor extraction (SVE)
- Reduction/oxidation (Redox) manipulation (RM)
- Free-Product Recovery (FPR)
- Pump and treat (P&T)

Each of these technologies is described in the alternative descriptions below. These technologies were assembled into five different alternatives to provide realistic options that could be implemented based on the information gathered during the feasibility study. The no action alternative was also evaluated to form a baseline for comparing the other alternatives.

Thus, six remedial action alternatives were developed for OU 8. Alternatives were assembled to represent varying levels of remedial action ranging from “no action” to treatment of chemicals of concern. Total costs presented below represent the present worth costs for ten years assuming a five percent discount factor. ARARs that each cleanup alternative will attain are also discussed in this section. The term Major ARARs is being used to identify those ARARs that provide a basis for developing an alternative (e.g., cleanup levels for groundwater resources) or ARARs that help distinguish between alternatives.

9.1 ALTERNATIVE 1: NO ACTION

This alternative is used to evaluate future conditions at OU 8. The No Action alternative provides a useful baseline for comparing the effectiveness of other alternatives. Under the No Action alternative groundwater contaminants at OU 8 would continue to spread to uncontaminated areas. The no action alternative assumes a minimal capital cost of $230,000 to abandon the existing P&T and SVE systems. There are no operation and maintenance (O&M) costs associated with this alternative. By definition, no time would be needed to implement this alternative.

9.2 ALTERNATIVE 2: LTM+P&T+SVE+IC

The major components for this alternative include groundwater monitoring, groundwater containment, vadose zone soil treatment, and institutional controls.

Treatment Components

- SVE would remove soil vapor beneath the central PWIA. Soil vapor containing high VOC concentrations would be extracted from the existing SVE system and SVE network of wells that were installed in 1994. The extracted vapors would be treated using a catalytic oxidizer before being discharged to the atmosphere. Air emissions from this process would contain low levels of VOCs that are not expected to require additional treatment.

Containment Components

- P&T would hydraulically control the groundwater flow and would prevent further off-base migration of groundwater plume. However, P&T would not address contaminants that have migrated off base. Groundwater would be pumped from two extraction wells located at the base boundary and treated in an air stripper tower. The treated water would be reintroduced into the Shallow Aquifer. Air emissions from this process would contain low levels of VOCs that are not expected to require additional treatment. The P&T system would operate at 90 gpm.

General Components

- LTM would be used to monitor the movement of contaminants in groundwater and to monitor the effectiveness of SVE and P&T systems. Groundwater samples would be collected from existing monitoring wells located on- and off-base on a quarterly basis, with the potential to reduce the frequency at a later time, if warranted. Groundwater samples would be analyzed for VOCs that include the COCs. Groundwater monitoring would be continued until contaminant concentrations are below the cleanup goals.

- Institutional Controls (ICs) have already been implemented to prevent human exposure to contaminated groundwater by preventing the use and consumption of untreated groundwater. Off-base ICs include: (1) prohibition on water supply well installation within OU 8 into the Shallow Aquifer, and (2) negotiated water use agreements with private landowners in the Mountain View neighborhood to provide an alternate water supply. As part of the voluntary time-critical removal action in 1995, the Navy connected the Mountain View residents in the impacted

area to a municipal water supply to prevent human exposure to contaminated groundwater. The Navy paid the cost of an estimated 3-year water service on a one-time lump sum basis. There is no plan for the Navy to connect additional private properties to the municipal water supply. The water use agreement is recorded with the Kitsap County Auditor office and is a legal agreement that "run with the land" and is legally binding to subsequent private property owners. The Navy will notify the Kitsap County Health District when the off-base groundwater is cleaned up to the drinking water standards. The Health District will determine if groundwater is safe for human consumption. On base, the Navy will implement a SUBASE Bangor Institutional Controls Management Plan (ICMP) that prohibits installation of water supply wells within OU 8 into the Shallow Aquifer.

- Implementation of this alternative does not pose any unusual or extraordinary conditions. The recovery wells have already been installed. This alternative could be implemented using standard methods and equipment that are readily available.

Major ARARs

- The COCs identified in the risk assessments have federal and state chemical-specific cleanup levels (Table 8-1). OU 8 groundwater will be treated and monitored until the cleanup goals are met (Table 8-1). Given that the primary future beneficial use of OU 8 Shallow Aquifer is for domestic water supply and that the future land use of the off-base portion of OU 8 will remain residential, the Navy is establishing an initial cleanup goal for off-base groundwater. This initial cleanup goal is to achieve the drinking water standards (MCLs or MTCA Method B cleanup levels) in off-base groundwater. Off-base institutional controls will be implemented until the drinking water standards are reached in the off-base groundwater. The results of the RI report indicated that there is very little difference between the removal of benzene and DCA under pumping or non-pumping scenarios. The existing groundwater extraction system prevented downgradient migration of contaminants, however removed only small amounts of the contaminants as compared to the ongoing natural attenuation. The Navy anticipates that the time frame to achieve the cleanup goal for natural attenuation will be by the year 2008. The progress towards the initial cleanup goal will be monitored using wells located at the base boundary and on Mountain View Road.

- If necessary, off-gas emissions from the air stripper of the P&T system and the catalytic oxidizer of the SVE system would be treated to meet requirements of the Clean Air Act (CAA) and the Puget Sound Clean Air Agency (PSCAA). Wastes (e.g., purge groundwater) generated during the implementation of the cleanup

alternative would be disposed of in accordance with the Resource Conservation and Recovery Act (RCRA) Hazardous Waste requirements, if necessary

9.3 ALTERNATIVE 3: MNA+RM+IC

The major components for this alternative include natural attenuation, groundwater treatment, and institutional controls.

Treatment Components

- Contaminant concentrations and geochemical parameters in groundwater would be monitored to document the rate of natural attenuation. Natural attenuation processes include chemical (biodegradation, chemical and biochemical stabilization) and physical processes (dispersion, dilution, sorption, and volatilization). As discussed in detail in the Feasibility Study, a two-phase groundwater investigation was conducted at OU 8 expressly to evaluate whether natural attenuation was taking place and if the conditions are favorable for it to continue. The investigations assessed plume stability, groundwater chemical conditions, presence of nutrient and food sources (contaminants being the food for microorganisms), and the presence of "daughter" or degradation products from the chemicals being degraded. The conclusions are that natural attenuation is taking place and conditions are quite favorable for it to continue. The presence of DCA is a primary example of how the natural biological process of reductive chlorination has degraded trichloroethane (an industrial solvent) to the "daughter product" of DCA. Further reductive chlorination transforms the DCA to chloroethane and finally ethane (ethanol). Groundwater monitoring and modeling have indicated that the benzene and DCA concentrations at the base boundary and in the Mountain View neighborhood are expected to attenuate to levels below drinking water standards by the year 2008.

- RM would be used to increase the dissolved oxygen and stimulate the biological activity of microorganisms in groundwater. For Alternative 3, ten bio-sparging wells would be installed at the base boundary. At this location, the surface topographic elevation is low, which suggests a likely location of groundwater recharge. A pilot test would be required to determine whether RM (bio-sparging) can be implemented and if so, to determine the final design parameters of the system.

General Components

- Groundwater sampling will be used to monitor the movement of contaminants in the groundwater and to monitor the effectiveness of natural attenuation.

Monitoring would be conducted using existing on-base and off-base monitoring wells. It is estimated that 20 wells would be sampled and analyzed in each sampling event. Sampling would initially be conducted on a semiannual basis, with the potential to reduce the frequency at a later time, if warranted. Groundwater samples would be analyzed for VOCs and natural attenuation parameters. Groundwater monitoring would be continued until contaminant concentrations are below the cleanup levels.

- Groundwater sampling results will be used to verify that natural attenuation is reducing contaminant concentrations in OU 8 groundwater at a rate that will meet the cleanup goal. If, during subsequent reviews, sampling results indicate that contaminant concentrations in groundwater are not being reduced through natural attenuation, prior to movement off base, the existing P&T would be used to contain the portion of the groundwater plume on base. MNA would be continued until contaminant concentrations are below the cleanup levels.

- Institutional controls as described in Alternative 2 would be implemented as part of this alternative.

- Implementation of this alternative does not pose any unusual or extraordinary conditions. This alternative could be implemented using standard methods and equipment that are readily available. However RM may be difficult to implement over large areas because of the potential for restrictions on air flow through the aquifer related to the heterogeneity of soils and preferential pathways of the more permeable soil. It is estimated that enhancing natural attenuation would reduce contaminant concentrations in the off-base Shallow Aquifer to levels below the drinking water standards by the year 2008. Groundwater data at OU 8 indicate that natural attenuation is taking place. The data indicate that contaminant concentrations in the off-base portion of OU 8 have been decreasing and that the horizontal extent of the contaminant plume has not increased during the last five years.

Major ARARs

- The COCs identified in the risk assessments have federal and state chemical-specific ARARs. The remedy will be in place until the OU 8 achieves the cleanup levels (Table 8- 1). Given that the primary future beneficial use of OU 8 Shallow Aquifer is for domestic water supply and that the future land use of the off-base portion of OU 8 will remain residential, the Navy established an initial cleanup goal for off-base groundwater. The initial cleanup goal is to apply MNA to achieve the drinking water standards (MCL) in off-base groundwater. Off-base institutional controls will be implemented until the drinking water standards are

reached in the off-base groundwater. The Navy anticipates that the time frame to achieve the cleanup goal for natural attenuation will be accomplished by the year 2008. The progress towards the initial cleanup goal will be monitored using wells located at the base boundary and on Mountain View Road.

9.4 ALTERNATIVE 4: MNA+FPR+IC

The major components for this alternative include natural attenuation monitoring, source removal by free-product recovery, and institutional controls.

Treatment Components

- Contaminant concentrations in groundwater will be allowed to naturally attenuate as described in Alternative 3.

General Components

- MNA as described in Alternative 3 would be implemented as part of this alternative.

- FPR would remove the LNAPL in the PWIA service station area, which is the principal threat to OU 8 groundwater. The LNAPL would be removed by an active skimming method. A portion of the volume of LNAPL will be considered recoverable fuel. The FPR system would be installed in existing monitoring wells where LNAPL is present. Based on field measurements and the extent of LNAPL beneath the PWIA, it is estimated that a maximum of 13,000 gallons of LNAPL remains underneath the PWIA. The LNAPL will be recovered until the practicable endpoint (a total recovery rate of 0.5 gallons per month for a one year period) is achieved.

- Recovered LNAPL would be recycled by re-using as fuel or disposed of as waste oil/petroleum.

- Institutional controls as described in Alternative 2 would be implemented as part of this alternative.

- Implementation of this alternative does not pose any unusual or extraordinary conditions. This alternative could be implemented using standard methods and equipment that are readily available. It is estimated that natural attenuation would reduce contaminant concentrations in the off-base Shallow Aquifer to levels below the drinking water standards by the year 2008. Groundwater data at OU 8 indicate that natural attenuation is taking place. The data indicate that

contaminant concentrations in the off-base portion of OU 8 have been decreasing and that the horizontal extent of the contaminant plume has not increased during the last five years.

Major ARARs

- The COCs identified in the risk assessments have federal and state chemical-specific cleanup levels (Table 8-1). OU 8 groundwater will be treated and monitored until the cleanup levels are met (Table 8-1). Given that the primary future beneficial use of OU 8 Shallow Aquifer is for domestic water supply and that the future land use of the off-base portion of OU 8 will remain residential, the Navy established an initial cleanup goal for off-base groundwater. The initial cleanup goal is apply MNA to achieve the drinking water standards (MCLs) in off-base groundwater. Off-base institutional controls will be implemented until the drinking water standards are reached in the off-base groundwater. The Navy anticipates that the time frame to achieve the cleanup goal for natural attenuation will be by the year 2008. The progress towards the initial cleanup goal will be monitored using wells located at the base boundary and on Mountain View Road.

- Wastes (e.g., purge groundwater and LNAPL) generated during the implementation of the cleanup alternative would be transferred to SUBASE Bangor's Recycling and Waste Program in accordance with the Washington State Dangerous Waste Regulations (WAC 173-303) and the Resource Conservation and Recovery Act (RCRA) Hazardous Waste requirements, if necessary.

- The LNAPL will be recovered until the practicable recovery endpoint (a total recovery rate of 0.5 gallons per month for a one-year period) is achieved for the entire recovery system. Post recovery monitoring intended to gauge residual product thickness in the recovery wells, and monitoring of adjacent wells for product, will be initiated to confirm that the practicable recovery endpoint has been achieved and that significant thicknesses of product are not migrating to new areas.

9.5 ALTERNATIVE 5: MNA+SVE+IC

The major components for this alternative include natural attenuation monitoring, vadose zone soil treatment by soil vapor extraction, and institutional controls.

Treatment Components

- Contaminant concentrations in groundwater will be allowed to naturally attenuate as described in Alternative 3.

General Components

- MNA as described in Alternative 3 would be implemented as part of this alternative.
- SVE as described in Alternative 2 would be implemented as part of this alternative. The SVE wells network would be expanded to include additional 18 new wells.
- Institutional controls as described in Alternative 2 would be implemented as part of this alternative.
- Implementation of this alternative does not pose any unusual or extraordinary conditions. This alternative could be implemented using standard methods and equipment that are readily available. It is estimated that natural attenuation would reduce contaminant concentrations in the off-base Shallow Aquifer to levels below the drinking water standards by the year 2008. Groundwater data at OU 8 indicate that natural attenuation is taking place. The data indicate that contaminant concentrations in the off-base portion of OU 8 have been decreasing and that the horizontal extent of the contaminant plume has not increased during the last five years.

Major ARARs

- The COCs identified in the risk assessments have federal and state chemical-specific ARARs. OU 8 groundwater will be monitored until the cleanup levels are met (Table 8-1). Given that the primary future beneficial use of OU 8 Shallow Aquifer is for domestic water supply and that the future land use of the off-base portion of OU 8 will remain residential, the Navy established an initial cleanup goal for off-base groundwater. The initial cleanup goal is apply MNA to achieve the drinking water standards (MCLs) in off-base groundwater. Off-base institutional controls will be implemented until the drinking water standards are reached in the off-base groundwater. The Navy anticipates that the time frame to achieve the cleanup goal for natural attenuation will be by the year 2008. The progress towards the initial cleanup goal will be monitored using wells located at the base boundary and on Mountain View Road.
- If necessary, off-gas emissions from the catalytic oxidizer of the SVE system would be treated to meet requirements of the Clean Air Act (CAA) and the Puget Sound Clean Air Agency (PSCAA). Wastes (e.g., purge groundwater) generated during the implementation of the cleanup alternative would be disposed of in

accordance with the Resource Conservation and Recovery Act (RCRA) Hazardous Waste requirements, if necessary.

9.6 ALTERNATIVE 6: LTM+FPR+SVE+IC

The major components for this alternative include groundwater monitoring, source removal by free-product recovery, vadose zone soil treatment by soil vapor extraction, and institutional controls.

Treatment Components

- SVE as described in Alternative 2 would be implemented as part of this alternative.

Containment Components

- FPR as described in Alternative 4 would be implemented as part of this alternative.

General Components

- LTM as described in Alternative 2 would be implemented as part of this alternative.
- Institutional controls as described in Alternative 2 would be implemented as part of this alternative.
- Implementation of this alternative does not pose any unusual or extraordinary conditions. This alternative could be implemented using standard methods and equipment that are readily available.

Major ARARs

- The COCs identified in the risk assessments have federal and state chemical-specific cleanup levels (Table 8-1). OU 8 groundwater will be treated and monitored until the cleanup levels are met (Table 8-1). Given that the primary future beneficial use of OU 8 Shallow Aquifer is for domestic water supply and that the future land use of the off-base portion of OU 8 will remain residential, the Navy established an initial cleanup goal for off-base groundwater. The initial cleanup goal is apply MNA to achieve the drinking water standards (MCLs) in off-base groundwater. Off-base institutional controls will be implemented until the drinking water standards are reached in the off-base groundwater. The

progress towards the initial cleanup goal will be monitored using wells located at the base boundary and on Mountain View Road.

- If necessary, off-gas emissions from the air stripper of the P&T system and the catalytic oxidizer of the SVE system would be treated to meet requirements of the Clean Air Act (CAA) and the Puget Sound Clean Air Agency (PSCAA). Wastes (e.g., purge groundwater and LNAPL) generated during the implementation of the cleanup alternative would be characterized and disposed of in accordance with the Resource Conservation and Recovery Act (RCRA) Hazardous Waste requirements.

10. SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

CERCLA, as amended by SARA, requires that the specific statutory requirements listed below be addressed in the ROD and supported by the administrative record. Under CERCLA, remedial actions must meet these requirements:

- Protect human health and the environment
- Attain ARARs unless justifications are provided for invoking a waiver
- Be cost-effective
- Use permanent solutions and alternative technologies or resource recovery technologies to the maximum extent practicable
- Address the preference for treatment that reduces contaminant toxicity, mobility, or volume

In addition, CERCLA emphasizes long-term effectiveness and encourages the evaluation of innovative technologies. To address these requirements, EPA has developed nine evaluation criteria as the basis for the detailed feasibility study evaluation and, subsequently, for selecting an appropriate remedial action. EPA groups the nine criteria into three categories, based on each criterion's role during remedy selection. Figure 10-1 depicts the EPA evaluation criteria. A description of each criterion is presented along with the evaluation of each alternative in the following sections.

The RAOs for OU 8 are as follows:

- Minimize the migration of VOCs from LNAPL beneath the PWIA into groundwater at concentrations that would cause adverse non-cancer health effects or unacceptable cancer risks. This would be accomplished by recovering free product to reduce an ongoing source of groundwater contamination on base and off base and to reduce the source of residual soil contamination on base, which will help reduce the potential adverse non-cancer health effects or unacceptable cancer risks.
- Minimize human exposure to COCs in site-wide groundwater that would result in adverse non-cancer health effects or unacceptable cancer risks. This will be accomplished by continuing management and implementation of institutional controls both on base and off base to minimize human exposure related to COCs in site-wide groundwater and implementation of MNA to achieve cleanup goals.

The area of attainment is defined as the area that will achieve the remedial action objectives after remediation is completed. The area of attainment for OU 8 is the site-wide (on-base and off-base) groundwater.

Under each criterion, the alternatives are presented in order from high to low, relative to how well the are satisfied. A comparison of the alternatives with each other under each criterion summarizes the Navy's analysis conducted in the Feasibility Study.

The "No Action" alternative does not provide overall protection of human health and the environment, nor does it meet ARARs for OU 8. Because the Navy cannot select an alternative that does not satisfy EPA's evaluation criteria, this alternative is not carried forward for evaluation beyond the threshold criteria.

10.1 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

This criterion addresses whether each alternative provides adequate protection of human health and the environment and describes how risks posed through each exposure pathway are eliminated, reduced, or controlled through treatment, engineering controls, and/or institutional controls.

Institutional control is included in alternatives to prevent the human exposure to contaminated groundwater. In terms of overall protection of human health, the alternatives may be ranked in the following order (highest to lowest):

Alternative 4 > Alternative 2/Alternative 3/Alternative 5 > Alternative 6 > Alternative 1

Under Alternative 1 (No Action), no treatment would be performed and no engineering controls would be provided to treat COCs. Existing site conditions would prevail.

Alternative 2 (LTM+SVE+P&T+IC) is protective of human health and the environment by containing and by transferring VOCs from the liquid phase to the vapor phase as contaminated water is pumped and passed through an air stripper, and by removing VOC vapor from the unsaturated soil zone. However, P&T will not address contaminants that have migrated off base. In addition, the principal threat to OU 8 groundwater, LNAPL beneath the PWIA, will not be addressed.

Alternative 3 (MNA+RM+IC) reduces the potential for exposure to contaminated groundwater through monitored natural attenuation with supplemental redox manipulation and institutional controls. RM stimulates biological activities; therefore, enhances natural attenuation. However, the principal threat to OU 8 groundwater, LNAPL beneath the PWIA, is not addressed.

Alternative 4 (MNA+FPR+IC) reduces the potential for exposure to contaminated groundwater

through the use of natural attenuation with source removal. This alternative can be implemented in the shortest time and addresses both VOCs in groundwater and LNAPL beneath the PWIA. Alternative 5 (MNA+SVE+IC) reduces the potential for exposure to contaminated groundwater through monitoring natural attenuation and vadose zone soil treatment. This alternative does not address the principal threat to OU 8 groundwater, LNAPL beneath the PWIA. Alternative 6 (LTM+FPR+SVE+IC) is protective of human health and the environment by removing the LNAPL beneath the PWIA and VOC soil vapor from vadose zone soil. However, this alternative does not address VOCs in groundwater.

Alternatives 3, 4, and 5 rely on natural attenuation to reduce concentrations of contaminants in groundwater. Monitored natural attenuation would provide data to determine long-term protection to human health and the environment and to determine the need for additional remedial measures. Conditions favorable to natural attenuation exist at OU 8. The Monitoring conducted as part of the monitored natural attenuation process serves several purposes, these include: (1) ensure natural attenuation is continuing to take place; (2) assess the rate of attenuation to ensure remedial goals can be achieved within the desired timeframe; and (3) to monitor the extent of the contaminant plume. With the exception of Alternative 1, all alternatives incorporate institutional controls (ICs) to help protect human health and the environment.

10.2 COMPLIANCE WITH ARARs

Section 121(d) of CERCLA and the NCP 40 CFR 300.430(f)(1)(ii)(B) require that remedial actions at CERCLA sites attain legally applicable or relevant and appropriate requirements (ARARs) or other federal and state standards, criteria and limitations unless specific ARARs are waived under CERCLA section 121(d)(4).

Applicable requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be applicable. Relevant and appropriate requirements address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site.

ARARs are grouped into these three categories:

Chemical Specific ARARs are health or risk-based numerical values or methodologies which, when applied to site specific conditions, result in establishment of the amount or concentration that may be found in, or discharge to, the environment.

Location Specific ARARs restrict the concentration of hazardous substances or the conduct of activities solely because they are in specific locations such as flood plains, wetlands, historic places, and sensitive ecosystems or habitats.

Action Specific ARARs are usually technology or activity-based requirements or limitations on actions taken with respect to hazardous wastes.

Table 8-1 summarizes the Federal and State ARARs that the selected remedy will attain. The primary ARARs for all alternatives are the chemical-specific ARARs. Alternative 1 does not meet the chemical specific ARARs for groundwater. Under Alternative 2, P&T will minimize further off-base migration of contaminants through actively pumping and containing the groundwater plume. Given that P&T will not address contaminants that have migrated off base, the off-base portion of OU 8 will not meet the chemical-specific ARARs for groundwater. Alternatives 3, 4, and 5 will meet chemical-specific ARARs only if site conditions are favorable for natural attenuation. Natural attenuation will reduce contaminant concentration to levels below the cleanup levels over time. If natural attenuation proves to be ineffective in a reasonable time frame, additional remedial measures will be conducted so that groundwater will meet the cleanup levels. Alternative 6 will not meet the chemical-specific ARAR because this alternative does not address VOCs in groundwater.

10.3 LONG-TERM EFFECTIVENESS AND PERMANENCE

Long-term effectiveness and permanence refers to expected residual risk and the ability of a remedy to maintain reliable protection of human health and the environment over time, once cleanup levels have been met.

In terms of long-term effectiveness and permanence, the alternatives may be ranked in the following order (highest to lowest):

Alternative 4 > Alternative 3/Alternative 2/Alternative 5 > Alternative 6 > Alternative 1

Alternative 1 will not provide long-term effectiveness in reducing the potential movement of contaminated groundwater. Alternative 2 will reduce the potential movement of contaminated groundwater through pumping; however, contaminants in the off-base groundwater will not be removed. Alternatives 3, 4, and 5 use natural attenuation to reduce contaminant concentrations in groundwater to meet the cleanup levels. Because natural attenuation processes occur without human intervention, MNA provides long-term effectiveness and permanence to maintain reliable protection of human health and the environment after cleanup levels have been met. The rate at which natural attenuation processes achieve the cleanup goals will be evaluated during the implementation of MNA. Alternative 4 ranks the highest among the alternatives that include MNA because Alternative 4 includes a component for source control. Alternative 6 ranks lower than alternative 3 because alternative 6 is mechanically complex resulting in unreliable

Alternative 1 (No Action)	Alternative 2 (LTM+SVE+P&T+IC)	Alternative 3 (MNA+RM+IC)
Alternative 4 (MNA+FPR+IC)	Alternative 5 (MNA+SVE+IC)	Alternative 6 (LTM+FPR+SVE+IC)

performance. Also Alternative 6 has no action for directly treating or cleaning up groundwater. Alternative 6 will not provide long-term effectiveness, but will minimize further dissolution of VOCs from LNAPL into groundwater.

10.4 REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

This criterion evaluates use of treatment to reduce the harmful effects of principal contaminants, their ability to move in the environment, and the amount of residual contamination remaining.

In terms of reduction of toxicity, mobility, or volume through treatment, the alternatives may be ranked in the following order (highest to lowest):

Alternative 4 > Alternative 3/Alternative 5 > Alternative 2 > Alternative 6 > Alternative 1

Alternative 1 does not reduce the toxicity, mobility, or volume of contaminated groundwater or LNAPL beneath the PWIA.

Alternative 2 relies on pumping to reduce the mobility of contaminated groundwater by minimizing further off-base migration of contaminated groundwater. This alternative does not reduce toxicity or volume of contaminants through treatment.

Alternatives 3, 4, and 5 rely on natural attenuation to reduce the toxicity, mobility, and volume of contaminants. Natural attenuation processes include a variety of biological, chemical, and physical processes. The most important components of natural attenuation is biodegradation where microorganisms cause chemical reactions that change the form of the contaminants to non-hazardous compounds; therefore, reduce the toxicity and volume of contaminants. The physical processes such as sorption reduce the mobility of the contaminants. Alternative 4 has a component that removes LNAPL beneath the PWIA and thus reduces the toxicity, mobility, and volume of the principal threat to OU 8 groundwater. Alternative 4 ranks the highest among the alternatives that include MNA, because it includes a component for source control.

Alternative 6 has a component that removes LNAPL beneath the PWIA and reduces toxicity, mobility and volume of principal threat at OU 8. However, this alternative does not address VOCs in groundwater.

10.5 SHORT-TERM EFFECTIVENESS

Short-term effectiveness considers the short-term risks that might be posed to the community and remedial workers during the implementation of the alternative, and the potential environmental impacts of the remedial action and the effectiveness and reliability of mitigative measures during implementation and time until protection is achieved.

Alternative 1 (No Action)	Alternative 2 (LTM+SVE+P&T+IC)	Alternative 3 (MNA+RM+IC)
Alternative 4 (MNA+FPR+IC)	Alternative 5 (MNA+SVE+IC)	Alternative 6 (LTM+FPR+SVE+IC)

In terms of short-term effectiveness, the alternatives may be ranked in the following order (highest to lowest):

Alternative 1 > Alternative 2 > Alternative 3/Alternative 4/Alternative 5/Alternative 6

The results from the computer models indicate that natural attenuation will clean up the off-base portion of OU 8 to the drinking water standards within ten years, by the year 2008. The mass balance calculations show that when P&T was operational, it only accounted for 20% of the total contaminant mass removed. In evaluating the short-term effectiveness, each alternative was evaluated independently of other alternatives. Therefore, alternatives that do not include MNA as a cleanup technology would not benefit from natural attenuation. Therefore, cleanup timeframes did not provide a clear distinction between alternatives. The alternatives were ranked based on the remediation. workers and nearby residents risk of exposure to COCs during remedial construction.

It is not anticipated that the proposed alternatives will significantly impact the surrounding residents, the environment, or health and safety of workers during the implementation period. Alternatives 1 and 2 pose no active remediation. Alternative 2 consists of utilizing existing components. Alternatives 3, 4, 5 and 6 may impact health and safety of workers through dust emissions and exposure to chemicals in the soil and groundwater during the initial construction phase. Alternative 3 requires construction of bio-sparging wells. Alternative 4 involves installation of a free-product recovery system within existing monitoring wells. Alternatives 5 and 6 involve upgrades to the existing SVE system. Personal protective equipment will be used to mitigate potential risks to workers during implementation of the remedial alternative. If necessary, engineering controls for dust suppression will be implemented. Standard practice as included in the Health and Safety Plan, workers are not allowed to eat or smoke within the designated hot zone. This will minimize workers potential for exposure via accidental ingestion or dermal contact with COCs in groundwater. Residents will not be allowed in the hot zone during construction activities.

10.6 IMPLEMENTABILITY

Implementability addresses the technical and administrative feasibility of a remedy from design through construction and operation. Factors such as availability of services and materials, administrative feasibility, coordination with other governmental entities, and whether the technology has been used successfully at similar sites are considered.

Alternative 1 (No Action)	Alternative 2 (LTM+SVE+P&T+IC)	Alternative 3 (MNA+RM+IC)
Alternative 4 (MNA+FPR+IC)	Alternative 5 (MNA+SVE+IC)	Alternative 6 (LTM+FPR+SVE+IC)

In terms of Implementability, the alternatives may be ranked in the following order (highest to lowest):

Alternative 1 > Alternative 2 > Alternative 4/Alternative 5/Alternative 6 > Alternative 3

In general, the more activity involved in construction and operation of an alternative, the more likely it is that difficulties would be encountered during implementation. With exception of Alternative 3, the remaining alternatives require no special or unique activities and could be implemented with readily available equipment, materials, and methods. Alternative 1 requires minimal effort to abandon the existing SVE and P&T systems. Alternative 2 consists of LTM and existing SVE and P&T systems. These systems have proven to be reliable within its capacity limits. Periodic repairs or equipment replacement to these systems would be expected. Based on the past performance, an air discharge permit would not be required.

Alternatives 3, 4, and 5 rely primarily on natural attenuation to address VOCs in groundwater. Alternative 3 uses RM to increase dissolved oxygen in groundwater and enhance biological activity. RM technology is relatively new and depends on subsurface properties. A site-specific pre-design study would be required to determine the final design parameters for the RM system. Alternative 4 uses free-product recovery to remove LNAPL beneath the PWIA. Free-Product Recovery is a proven technology that has been used at sites where LNAPL is present. Alternative 5 involves upgrades of the existing SVE system. SVE is a proven technology that has been effectively used to cleanup petroleum contaminated soil. Alternative 6 involves installation of free-product recovery and upgrades of the existing SVE system. Both technologies are proven technologies that can be implemented at OU 8.

10.7 COST

Capital, operation and maintenance, and total present worth costs of the each alternative are summarized in Table 10-1. Based on EPA guidance, the cost estimates were developed to be accurate to a range of -30 percent to +50 percent, given the available information. Present worth calculations assume a discount rate of 5 percent.

The assessment of this criterion considers the capital and O&M costs associated with each of the alternatives. Costs were developed using the Remedial Action Cost Engineering and Requirements System (RACER), Means Building Cost Index, vendor estimates, and contractor experience. Alternatives are evaluated for cost in terms of both capital costs and long-term O&M costs necessary to ensure continued effectiveness of the alternatives. Capital costs include the sum of the direct capital costs (materials and labor) and indirect capital costs (engineering, licenses, permits). Long-term O&M costs include labor, materials, energy, equipment replacement, disposal, and sampling necessary to ensure the future effectiveness of the alternative.

Alternative 1 (No Action)	Alternative 2 (LTM+SVE+P&T+IC)	Alternative 3 (MNA+RM+IC)
Alternative 4 (MNA+FPR+IC)	Alternative 5 (MNA+SVE+IC)	Alternative 6 (LTM+FPR+SVE+IC)

Cost varies between the alternatives as a result of differences in the amount of materials and the level of effort required for each alternative.

In terms of cost, the alternatives may be ranked in the following order (highest to lowest, with highest being the least costly alternative):

Alternative 1 > Alternative 4 > Alternative 3 > Alternative 5 > Alternative 6 > Alternative 2

The least costly of the alternatives that include remedial actions is Alternative 4. The most costly alternative is Alternative 2, which is more than twice the cost of Alternative 4.

10.8 STATE/SUPPORT AGENCY ACCEPTANCE

The Washington State Department of Ecology concurs with the selected remedy for OU 8, Alternative 4, MNA+FPR+IC. The state provided comments on the remedial investigation, feasibility study, and Proposed Plan. In accordance with the requirements of the NCP, the State of Washington was also provided the opportunity to review and comment on the ROD. As a result of that review and after incorporating adequate responses to the comments into the respective documents, the state concurred with the remedy.

10.9 COMMUNITY ACCEPTANCE

A public meeting was held on May 16, 2000 to present the Proposed Plan to a broader community audience than those that had already been involved through the RAB. At the meeting, representatives from the Navy and Ecology answered questions about OU 8 and the remedial alternatives under consideration. The Navy also used this meeting to solicit a wider cross-section of community input on the reasonably anticipat1111ed future land use and potential beneficial groundwater used.

The Navy received three written comments and one oral comment during the public comment period (May 12 through June 13, 2000). The oral comment, provided at the May 16 public meeting conducted by the Navy, was repeated in one of the three written comments, thus a total of 3 comments were received. The Navy has addressed these comments in preparing this ROD by providing a response to comments in Section 14: Responsiveness Summary. Only one of the three comments was directly related to the proposed remedy for OU 8. None of the identified issues resulted in significant changes to the Navy's preferred alternative.

Alternative 1 (No Action)	Alternative 2 (LTM+SVE+P&T+IC)	Alternative 3 (MNA+RM+IC)
Alternative 4 (MNA+FPR+IC)	Alternative 5 (MNA+SVE+IC)	Alternative 6 (LTM+FPR+SVE+IC)

11. SELECTED REMEDY

Based on the requirements of CERCLA, comparative analysis using the nine criteria, public comments, and in consultation with EPA and Ecology, the Navy has determined that the selected alternative for OU 8 is Alternative 4, Monitored Natural Attenuation and Free-Product Recovery with Institutional Controls. This alternative includes phased contingent actions. The first contingent action is to perform Redox Manipulation (RM) to introduce oxygen into the groundwater, and the second is to re-start the existing containment system. Neither of these contingent actions would involve construction. An example of RM would be the use of a system to passively release oxygen to the groundwater. These alternatives would be used in the event that MNA does not appear to be meeting cleanup goals. Five-year reviews of the remedy will be required because potential contaminants will remain at OU 8 above health-based levels during the use of natural attenuation. The objectives of this selected remedy are to:

- Minimize the migration of VOCs from LNAPL beneath the PWIA into groundwater at concentrations that would cause adverse non-cancer health effects or unacceptable cancer risks. This would be accomplished by recovering free product to reduce an ongoing source of groundwater contamination on base and off base and to reduce the source of residual soil contamination on base, which will help reduce the potential adverse non-cancer health effects or unacceptable cancer risks.

- Minimize human exposure to COCs in site-wide groundwater that would result in adverse non-cancer health effects or unacceptable cancer risks. This will be accomplished by continuing management/implementation of institutional controls on base and off base to minimize human exposure related to COCs in site-wide groundwater and implementation of MNA to achieve cleanup goals.

The selected remedy will meet the remedial objectives and reduce the potential risk for OU 8 by preventing future exposure to contaminants in groundwater.

11.1 SOIL

Petroleum contaminated soil beneath the PWIA service station was identified as a medium of concern because it represents a secondary source for release of petroleum to groundwater. The Navy has successfully addressed the contaminated soil from surface to a depth of 15 feet bgs within Ecology's UST Program. In February 2000, Ecology notified SUBASE Bangor that no further action was necessary to cleanup soil beneath the PWIA to a depth of 15 feet bgs.

There are no human health risks or ecological risks related to the exposure to contaminated soil beneath the PWIA service station. Because soil does not represent a risk to human health, the Navy does not propose an active means of addressing soil contamination. There is residual contamination in soil from 15 feet bgs to the water table that is related to floating free product (LNAPL) on the water table. The free-product recovery system will address the source of groundwater contamination and the residual soil contamination on base. After the LNAPL has

been removed to the extent practicable, the groundwater remedy will remain in place until groundwater meets cleanup goals, at which time the residual soil contamination will no longer represent a source or pose a threat to groundwater quality. Accordingly, the residual contaminants in soil from a depth of 15 feet bgs to the water table do not need to be actively addressed in this remedy. The status of the groundwater cleanup goals and residual soil contaminants will be evaluated within the 5-year review process.

Based upon the results of the subsurface soil and soil vapor samples collected during the OU 8 Source area investigation (RI), and sample results from previous investigations, an active source of chlorinated VOCs was not identified in the subsurface soil beneath the PWIA. Therefore, there is no active remediation proposed for VOCs in soil.

11.2 GROUNDWATER

The primary chemicals of concern at OU 8 are benzene and DCA in groundwater. Benzene and DCA are two of the more frequently detected contaminants exceeding the drinking water standards and the MTCA Method B cleanup standards. Based on the 1995/96 risk assessment, three other risk-based COCs (EDB, DCE, and toluene) were detected at concentrations exceeding the drinking water standards and the MTCA Method B cleanup standards, but do not represent a significant percentage of the overall risk. All COCs from OU 8 exceeding the cleanup standards are subject to this remedial action and must meet the cleanup standards (WAC 173-340-720[3][a][ii][B]).

The selected remedy for groundwater includes the following components.

- Monitored Natural Attenuation
- Phased Contingent Actions

The selected remedy will meet the remedial objectives and reduce the potential risk for OU 8 by preventing future exposure to contaminants in groundwater. The selected remedy will accomplish the remedial action objectives through the following:

- Conduct performance monitoring of natural attenuation in the Shallow Aquifer using existing monitoring wells. As a preliminary estimate, groundwater samples will be collected from approximately 20 monitoring wells.

- Conduct compliance monitoring for specified risk-based COCs and toxic degradation products (e.g. vinyl chloride) to determine compliance with the chemical specific cleanup standards.

As a preliminary estimate, the groundwater samples will be analyzed for the following MNA performance parameters to determine if conditions are supportive of natural attenuation processes, and for the specified risk-based COCs and toxic degradation products (e.g. vinyl chloride) to monitor the plume extent and compliance with cleanup standards.

Alkalinity	EPA Method 310.1
Dissolved Organic Carbon	EPA Method 415.1/415.2
Chloride	EPA Method 300
Sulfate	EPA Method 300
Nitrite Nitrogen	EPA Method 300
Nitrate Nitrogen	EPA Method 300
Benzene	EPA Method 8260
Toluene	EPA Method 8260
Ethylbenzene	EPA Method 8260
1,2-dibromoethane (EDB)	EPA Method 8260
1,2-dichloroethane (DCA)	EPA Method 8260
1,1-dichloroethene (DCE)	EPA Method 8260
1,1,2-trichloroethane	EPA Method 8260
1,2-dichloropropane	EPA Method 8260
Vinyl Chloride	EPA Method 8260
Ethane	EPA Method 3810 or RSK 175
Ethene	EPA Method 3810 or RSK 175
Hydrogen Sulfide	Field Analysis
Ferrous Iron	Field Analysis
Temperature	Field Analysis
Eh	Field Analysis
pH	Field Analysis
Conductivity	Field Analysis
Dissolved Oxygen (DO)	Field Analysis (Winkler Method)
Turbidity	Field Analysis

OU 8 groundwater will be monitored to evaluate the performance and effectiveness of the remediation system to achieve the cleanup goals and to determine if the remedy is meeting cleanup goals (compliance monitoring). The results of the monitoring and the status of the groundwater COCs will be reviewed annually. Details of the groundwater monitoring program will be determined during the design of the monitoring program and plan. If it is determined that natural attenuation does not make satisfactory progress in achieving protection of human health and the environment in a time frame comparable to that offered by other more active cleanup technologies, the contingency plan will be implemented.

It is predicted that contaminant concentrations in the off-base wells will be below the drinking water standards (MCLs) by the year 2008. Contaminant concentrations in the off-base wells should reach levels below drinking water standards (MCLs) faster than in the on-base wells. The monitoring program will be divided into two portions: off-base and on-base groundwater monitoring.

11.2.1 Off-Base Groundwater Monitoring will be conducted on a quarterly basis for the first year and on a semiannual basis thereafter. Monitoring consists of compliance monitoring for COCs and their toxic degradation products, and performance monitoring for MNA parameters. Performance monitoring will be discontinued after concentrations of COCs and their toxic degradation products decline and remain below the drinking water standards (MCLs) in off-base groundwater for a full year. Compliance monitoring may then be reduced in frequency to annual sampling for those COCs which have attained MCLs but have not yet attained their cleanup standards.

11.2.2 On-Base Groundwater Monitoring will be conducted on a quarterly basis for the first year and on a semiannual basis thereafter. Monitoring consists of compliance monitoring for risk-based COCs and toxic degradation products and performance monitoring for MNA parameters. After MCLs are achieved on-base, the performance and compliance monitoring will be conducted annually.

The sampling and analysis plan will specify wells to be monitored for performance monitoring and wells to be monitored for compliance.

11.3 PETROLEUM SOURCE CONTROL

The LNAPL presents an ongoing source of contamination to groundwater and residual soil. LNAPL has been observed in several wells in the vicinity of the PWIA service station. Removal of the LNAPL to the extent practicable will minimize the primary source of petroleum and reduce partitioning of VOCs to groundwater.

- Remove LNAPL using a free-product recovery system. Installation and continued analysis and monitoring of a free-product recovery system will be conducted. The system's performance will be reviewed annually to evaluate whether product recovery rates have become limited by the system's design, by the geologic or hydrogeologic conditions at the site, and if continued operation of the system is justified.

- The system will be operated until the recovery rate reaches the practicable recovery end point (the average of 0.5 gallons per month for a one-year period).

To the extent practicable, the Navy will attempt to implement modifications to the LNAPL recovery system as needed to accommodate LNAPL migration and other activities in the PWIA.

11.4 INSTITUTIONAL CONTROLS FOR OU 8

Continue implementation of Institutional Controls (ICs) that have already been implemented to prevent human exposure to contaminated groundwater by preventing the use and consumption of untreated groundwater. Off-base ICs include: (1) prohibition on water supply well installation within OU 8 into the Shallow Aquifer, and (2) negotiated water use agreements with private

landowners in the Mountain View neighborhood to provide an alternate water supply. As part of the voluntary time-critical removal action in 1995, the Navy connected the Mountain View residents in the impacted area to a municipal water supply to prevent human exposure to contaminated groundwater. The Navy paid the cost of an estimated 3-year water service on a one-time lump sum basis. There is no plan for the Navy to connect additional private properties to the municipal water supply. The water use agreement is recorded with the Kitsap County Auditor office and is a legal agreement that "runs with the land" and is legally binding to subsequent private property owners. The Navy will notify the Kitsap County Health District when the off-base groundwater is cleaned up to the drinking water standards. The Health District will determine if groundwater is safe for human consumption. On base, the Navy will implement a SUBASE Bangor Institutional Controls Management Plan (ICMP) that prohibits installation of water supply wells within OU 8 into the Shallow Aquifer.

ICs have already been implemented off base to prevent human exposure to contaminated groundwater. These controls prevent the use and consumption of untreated groundwater. On-base ICs exist through the SUBASE Bangor Environmental Program review process, but will be formalized in an Institutional Controls Management Plan as described below.

Institutional Controls for OU 8 can be broken down into two categories:

11.4.1 For the off-base portion of OU 8: The Navy connected residences located within or near the contaminated plume to a municipal water supply in 1995. In addition, negotiated water use agreements were prepared between the Navy and affected residents that prohibited household use of the groundwater. These agreements also state that residents are not to install new wells in the contaminated aquifer. Restrictions on well use and installation throughout the off-base portion of the plume are enforced by the Bremerton/Kitsap County Health District. Local requirements for new wells on developed or undeveloped land require individuals to go through an approval process administered by the Bremerton/Kitsap County Health District. Because the Health District discovered the first contaminated well off base, they have full knowledge of contaminants in site groundwater. They have stated that they will keep abreast of cleanup actions for OU 8 and will not certify new drinking water wells until the Health District has reviewed the water quality data and have determined that groundwater is safe for human consumption.

The water use agreements mentioned above are recorded with the Kitsap County Auditor's office. They are legal agreements that "run with the land" and are legally binding to subsequent private property owners. The Navy will provide monitoring data to the Bremerton/Kitsap County Health District so they can determine when the off-base groundwater is safe for human consumption. Figure 11-1 depicts the off-base areas affected by these water use agreements.

11.4.2 For the on-base portion of OU 8: The institutional control being implemented for on base is to prohibit constructions of drinking water wells within the entire OU 8 study area shown on Figure 1-2. SUBASE Bangor currently employs an Environmental Review Process for proposed new construction projects on the base to ensure environmental considerations are given to the project. One aspect of this review is compliance with RODs established for various

operable units. This process will be formalized in the base-wide Institutional Controls Management Plan (ICMP) currently under development. Specific procedures for implementing institutional controls at SUBASE Bangor are discussed separately in Section 11.8. Specific objectives of the control or restrictions include:

- No well drilling except for monitoring and remediation wells authorized in the EPA and state approved compliance and performance monitoring plans.
- Protect existing monitoring wells.
- Ensure land use does not jeopardize the integrity of the monitoring and/or remediation system.
- No use of groundwater except for monitoring unless otherwise approved by EPA and/or the state.
- Ensure on-base restrictions apply now and in the future, even if the U.S. Navy no longer has control of the property.

Ensure these restrictions are included in deed restrictions applied at the time that property is transferred to a non-federal entity.

11.5 CONTINGENCY REMEDY

Based on information obtained during the remedial investigation, two-phase natural attenuation study, computer modeling, and the analysis of alternatives, the Navy believes that the selected remedy will restore off-base groundwater to drinking water standards within a 10-year time frame. If it appears that the selected remedy is not making sufficient progress towards meeting remedial goals, the contingent actions will be discussed with all parties and implemented upon mutual concurrence. The contingency remedy considered for OU 8 includes installing an RM system at the base boundary to enhance biological activity in groundwater. If it is subsequently determined that RM did not increase the rate of natural attenuation, the containment system (P&T) could be used to contain or minimize further migration of the contaminant plume. The contingency cleanup technologies include installation of a passive RM system (ORC socks) to enhance natural attenuation processes. If it is determined that RM did not increase the rate of natural attenuation, the containment system (P&T) could be used to contain or minimize further migration of the contaminant plume. Essentially, neither component of the contingency require construction because the components are already in place.

The ability to achieve cleanup goals within the off-base portion of the contaminant plume will continue to be evaluated. Therefore, while this ROD selects the final remedy for OU 8, the Navy acknowledges that new technologies may become available that could result in a more cost-effective cleanup while ensuring reliable short- and long-term protection of human health and environment. Consistent with EPA's guidance, Superfund Reforms: Updating Remedy Decisions (OSWER No. 9200.0-22), the Navy will consider the availability and long-term effectiveness of possible new technologies whenever Ecology and EPA agree to undertake such action. An evaluation will occur at least every five years as part of the base-wide five-year review required under the Superfund rules.

11.6 SUMMARY OF RATIONALE FOR THE SELECTED REMEDY

The selected remedial alternative, Free-Product Recovery (FPR), NVA, and Institutional Controls (IC), is considered the best for this site because it best meets the nine USEPA evaluation criteria as specified in the NCP, and as discussed in Sections 9 and 10 of this ROD. The selected alternative is considered the most protective to overall human health and the environment, is relatively cost effective, and is easy to implement because natural attenuation is ongoing and the institutional controls are already being implemented as part of the 1995 time-critical cleanup action. The Washington State Department of Ecology has reviewed the proposed plan and draft-final ROD and has provided comments on both documents and concurs with the selected remedy for OU 8. The remedial alternative was presented to the community, and in general, the public comments were favorable to the Proposed Plan.

Natural attenuation is a well known and proven process that does not require human intervention, therefore remedial workers and the nearby community are not exposed to contaminants while implementing the remedial alternative. Also as most of the IC component has already been established, the selected remedy can be implemented easily and within a short period of time. ICs will prevent human and environmental exposure to VOCs by prohibiting activities that would result in exposure to VOCs. Reliability of ICs is high, both on base and off base.

Over time the VOCs in groundwater are reduced (mineralized) to harmless chemicals by the natural attenuation process. Groundwater modeling indicates that the VOCs in groundwater are expected to be reduced to levels below the chemical specific MCLs by the year 2008. The Feasibility Study (EA 2000) indicated that natural attenuation is ongoing and was the major contributor to reducing contaminants when the groundwater extraction system was operating. The selected remedy will document the degradation of VOCs in groundwater. LNAPL removal will address the principal threat to groundwater and augment the natural attenuation process by decreasing the mass of VOCs available to groundwater. For the selected remedy, reduction of risks due to VOCs, will be permanent because dissolved VOCs will be irreversibly degraded by natural attenuation and VOCs in LNAPL will be removed by the product recovery system. Sorbed VOCs in the vadose zone can be expected to degrade due to natural attenuation. MNA will demonstrate that the mass of dissolved phase VOCs is decreasing through the natural attenuation process.

The free-product recovery system installed at the PWIA service station in 1986 recovered approximately 6,000 gallons of LNAPL over a five-year period. Recovery rates then declined to near zero after the five years of operation (EA 2000). Based on lateral extent of LNAPL, LNAPL thickness measured in wells, and estimated porosity of saturated soil, the estimated maximum volume of LNAPL beneath the PWIA is approximately 13,400 gallons (EA 2000). Assuming 50 percent of this LNAPL can be recovered by extraction, approximately 6,700 gallons of LNAPL is available for removal (EA 2000). The product recovery system could be installed and operational within 6 months from the date that the ROD is signed.

11.7 INSTITUTIONAL CONTROLS FOR OTHER OPERABLE UNITS AT SUBASE BANGOR

In an effort to ensure compliance with the recently issued EPA guidance described below, Institutional Controls (ICs) for previously signed SUBASE Bangor RODs have been reviewed to determine if: 1) they exist as part of the remedy and 2) they are adequate to protect human health and the environment. This section provides site-specific IC requirements for each Operable Unit (OU) that requires them; locations of these OUs are shown on Figure 11-1.

EPA Region 10 recently issued a memorandum to establish a policy to ensure the short and long-term effectiveness of ICs being relied upon to protect human health and the environment at federal facilities. EPA defines ICs to include "all non-engineered restrictions on activities, access, or exposure to land, groundwater, surface water, waste and waste disposal areas and other areas of media. Some common examples of tools to implement ICs include restrictions on use of access, zoning, governmental permitting, public advisories, or installation master plans". The policy applies to decision documents such as RODs that are being prepared, as well as to RODs that were prepared prior to issuance of the policy. The policy states that for OUs where the ROD has been previously signed and IC requirements were not explicitly stated, a decision document such as an Explanation of Significant Differences (ESD) must be prepared adding the appropriate Institutional Control requirements. It allows for a decision document to be issued that covers all signed RODs for a facility. In lieu of issuing an ESD for the previously signed RODs, the ICs are being addressed in this ROD for OU 8.

11.7.1 OPERABLE UNIT 1 (SITE A)

For this site, there are two areas where IC objectives must be met. The first is throughout the Site A contaminated groundwater plume, and the second is at Debris Area 2, which was investigated as part of Site A.

Geographic location where ICs are required: Site A is located in the northwestern portion of the base at intersection of Pintado and Tinosa roads. According to the RI/FS, the area of contaminated groundwater lies underneath the former leach basin area, which is bounded on the west by Pintado Road and on the south by Tinosa Road. Groundwater flows in a northwesterly direction toward Cattail Lake and eventually discharges into Hood Canal. Therefore the objectives below will apply to groundwater that sits under the former leach basin, in addition to the area that would be included within a 600-foot radius of the basin's center. Objectives will also apply to groundwater flowing between Pintado Road and drainage to Cattail Lake.

Objectives of the control or restrictions:

- No well drilling except for monitoring wells authorized in the EPA and state approved monitoring plans
- Protect existing monitoring wells
- No use of groundwater except for monitoring unless otherwise approved by EPA and/or the state

- Ensure these restrictions apply now and in the future, even if the U.S. Navy no longer has control of the property
- Ensure these restrictions are included in deed restrictions applied at the time that property is transferred to a non-federal entity.

Comment: ICs were not specified in the ROD for OU 1 (Site A). Extraction of groundwater for groundwater remediation has been approved by the state.

Geographic location where ICs are required: Debris Area 2 is located approximately 400 feet south east of the former Site A leach basin, and the IC Objectives listed below apply to all of Debris Area 2.

Objectives of the control Restrictions:

- Maintain signs restricting access to the site
- Maintain blackberry cover limiting site access
- Ensure that all disturbed or excavated soils at or from the site are properly categorized and disposed of, and that workers are protected during any such disturbance or excavation.
- Ensure these restrictions apply now an in the future, even if the U.S. Navy no longer has control of the property
- Ensure these restrictions are included in deed restrictions applied at the time that property is transferred to a non-federal entity.

Comments: Blackberries were planted in lieu of placing a fence around this area to limit access.

11.7.2 OPERABLE UNIT 2 (SITE F)

Geographic location where ICs are required: Site F originates at the former ordnance wastewater lagoon, which was immediately west of the former segregation facility in the south central portion of the base. It is bounded both to the east and to the north by Trigger Avenue. The Naval Helicopter Pad is located approximately 700 feet to the northwest, and barricaded sidings and rail lines are located approximately 1,500 feet to the west. An infiltration barrier was placed over the lagoon as part of site remediation efforts, and a Recycling Retention Facility was later also placed at this site. The IC objectives listed below must be met for the infiltration barrier and throughout the plume of contaminated groundwater. As stated in the ROD for OU 2, contamination at Site F is restricted to the shallow aquifer. The objectives below will apply to the area originating at the former wastewater lagoon and extend south to the segregation facility access road, east to Trigger Avenue, north to the southeastern corner of SWFPAC, and west to the eastern edge of the SWFPAC laydown area (located almost directly across from Roosevelt Street on the south side of Trigger Avenue).

Objectives of the control or restrictions:

- Prevent any disturbance to the infiltration barrier, except as necessary for authorized O&M maintenance activities.
- Prevent any current or future land uses that could jeopardize the integrity or life of the infiltration barrier.
- Notify the state and EPA prior to any development or redevelopment of the site. The object of this notification is to ensure that the agencies concur that the development has been designed to retain the integrity of, and to avoid damage to, the infiltration barrier.
- No well drilling except for monitoring and remediation wells authorized in the EPA and state approved compliance and monitoring plans
- Protect existing monitoring wells
- No use of groundwater except for monitoring unless otherwise approved by EPA and/or the state
- Ensure these restrictions apply now and in the future, even if the U.S. Navy no longer has control of the property
- Ensure these restrictions are included in deed restrictions applied at the time that property is transferred to a non-federal entity.

Comment: ICs were not specified in the ROD for OU 2 (Site F) because they were considered to be a contingency remedy that would be put into place in the event that treatment of the groundwater was ineffective or no longer feasible. Extraction of groundwater for groundwater remediation has been approved by the state.

11.7.3 OPERABLE UNIT 3 (SITE 16/24 and 25)

Geographic location where ICs are required: Site 16/24 is a 1.5 acre site that is roughly rectangular in shape. It is approximately 200 feet south of Trident Boulevard and is west of Seadevil Road and northeast of Sculpin Circle. The ICs objectives listed below must be met throughout the Site 16/24 area.

Objectives of the control or restrictions:

- Ensure that land use at Site 16/24 remains industrial.
- Ensure that all disturbed or excavated soils at or from the site are properly categorized and disposed of, and that workers are protected during any such disturbance or excavation.
- Ensure that these restrictions apply now and in the future, even if the U.S. Navy no longer has control of the property.
- Ensure that these restrictions are included in deed restrictions applied at the time that property is transferred to a non-federal entity.

Comments: The IC included in the ROD for OU 3 (Sites 16/24) was to prevent soil contact. It restricted the building of any residential units on this site and was in place at the time the ROD was signed.

Geographic location where ICs are required: Site 25 is approximately 1.2 acres in size and is located at the southeast portion of the facility. It is bounded by Sculpin Circle to the north and west and by the Southern Boundary Road to the east. A residential area lies outside of the base boundary to the southeast. ICs apply to site groundwater with contaminants above cleanup standards.

Objectives of the control or restrictions: Because Site 25 is within the OU 8 area, ICs being applied at OU 8 would also cover this site. Therefore, Site 25 will not be specifically covered in the base-wide ICMP.

> Comments: The ROD for OU3 required five years of semiannual groundwater monitoring at Site 25 to verify that metals concentrations detected in the Shallow Aquifer are consistent with natural background concentrations. The Navy, EPA, and Ecology were to compare the monitoring data against federal drinking maximum contaminant levels (MCLs), MTCA Method B groundwater cleanup levels, and representative background concentrations to determine if additional monitoring or other actions were necessary. Samples from the first two semiannual rounds of post-ROD sampling were analyzed for metals as well as VOCs and SVOCs; samples from the first round were also analyzed for ordnance, and the second round for OC pesticides and PCBs. Detected benzene and BEP in select wells were attributed to nearby upgradient sources within OU 8; accordingly, the subsequent monitoring events included analysis for metals only. Because Site 25 is located within the capture zone for the OU 8 groundwater containment system while it operated, Site 25 field activities have been conducted concurrent with OU 8 activities. Semiannual monitoring of Site 25 groundwater quality has demonstrated that metals concentrations are below MTCA groundwater cleanup levels.
>
> Based on these analytical results, the Navy recommended discontinuation of the groundwater monitoring program for Site 25. Following review of the eight rounds of data and discussions between the Navy and Ecology, Ecology concurred with this recommendation. The Navy and Ecology agree that the groundwater monitoring completed for Site 25 meets the requirements of the OU 3 ROD, and that no additional monitoring is required.

11.7.4 OPERABLE UNIT 6 (SITE D)

Geographic location where ICs are required: Site D is located in the west central portion of the base, north of Sturgeon Street along the west side of Escolar Road. A majority of the Site D area is comprised of wetlands. While Site D soils exceed MTCA Method B due to DNT contamination, specific ICs are not required because existing wetlands laws and regulations will provide sufficient protection.

> Comments: The ROD for OU6 states that no deed restrictions or other administrative limitations on future land use were included in the alternative

selected, and that existing wetlands laws would prevent future development of Site D wetlands.

11.7.5 OPERABLE UNIT 7

The ICs placed in the ROD for OU7 are applicable to Sites B (Floral Point), E/11, and 10, and are addressed individually below.

11.7.5.1 Site B (Floral Point)

Geographic location where ICs are required: Site B is approximately 5 acres in size and is located along the Hood Canal at the northwestern portion of the facility. It is southwest of the Magnetic Silencing Facility and west of Amberjack Road. The ICs objectives listed below must be met throughout Floral Point:

Objectives of the control or restrictions:

- Prevent any disturbance to the cap, except as necessary for authorized O&M cap maintenance activities.
- Prevent any current or future land uses that could jeopardize the integrity or life of the cap.
- Notify the state and EPA prior to any development or redevelopment of the site. The object of this notification is to ensure that the agencies concur that the development has been designed to retain the integrity of, and to avoid damage to, the cap.
- Ensure that these restrictions apply now and in the future, even if the U.S. Navy no longer has control of the property.
- Ensure that these restrictions are included in deed restrictions applied at the time that property is transferred to a non-federal entity.

Comment: There were no ICs included as part of the remedy for Floral Point, only inspection and maintenance of the vegetative cap and shoreline protection system installed, and long term monitoring of off shore sediment and clam tissue as part of the five year review.

11.7.5.2 Site E/11

Geographic location where ICs are required: Site E/11 is located west of Site F in the south central portion of SUBASE Bangor, 1/2 mile north of Thresher Avenue. It is within the Site F area restricted for groundwater use.

Objectives of the control or restrictions: Due to the site's location, objectives for Site F are applicable to Site E/11.

Comment: Based on sampling results, the only remaining concern at Site E/11 is potential Otto Fuel contamination in groundwater. However, this sampling has shown Otto Fuel concentrations are now below drinking

water standards, which would indicate that the ICs are no longer required. A focused Otto Fuel monitoring program will be completed to-confirm compliance with the cleanup level. Regardless of these results, ICs for Site F will also cover the Site E/11 area since the Site F plume goes under Site E/11.

11.7.5.3 Site 10

Site 10 is located just west of the Public Works Industrial Area, across Scorpion Avenue on the west side of Guardfish Street. It is adjacent to Buildings 2011 and 2012, and is approximately 100 feet by 50 feet in size.

Soil: The ROD states that the cancer and non-cancer risk for future residents from chemicals in soil at Site 10 were found to be acceptable based on EPA criteria, and that the site was paved. It goes on to say that the pavement will be maintained to protect human health and the environment. However, Section 7.5.1 of the ROD also states that sampling data were reviewed, and it was determined that soils do meet MTCA requirements for unrestricted use. The one exceedance of Method B standards that occurred was for dieldrin; however, collectively the data passed the MTCA 3-fold criteria, and no chemicals of interest were identified. Based on this, there is no need for the asphalt to remain in place.

Groundwater: The ROD states that confirmatory sampling for TPH in groundwater will be conducted, and that ICs would be established to restrict groundwater use. Because sampling was not done, additional samples will be taken to determine if TPH is still a concern in the groundwater. Since Site 10 is located within the OU 8 area, ICs applied to OU 8 will also cover Site 10.

11.8 IMPLEMENTATION OF INSTITUTIONAL CONTROL

A schedule for the development and implementation of the Institutional Control Management Plan (ICMP) will be submitted to EPA and Ecology within 6 months of ROD signature. The ICMP will be implemented by establishing a SUBASE Bangor instruction. The ICMP and base instruction will be completed and in place within one year of the ROD signature. The ICMP will identify with geographic specificity all areas subject to the institutional controls selected in the ROD; identify the objectives of the institutional controls; specify the anticipated time frames that ICs are to remain in effect, identify what would be considered inconsistent with the institutional control objectives or protectiveness criteria and establish a procedure to avoid/prevent such activities, provide for the frequency and type (e.g., field inspection, process review, record review) of monitoring of the institutional controls; require an annual monitoring report; and identify current land users and uses. The annual monitoring report will provide a description of how facility wide requirements are met, including a checklist identifying results of field inspections, and documentation of any failures. The monitoring report will also identify if institutional controls are being met, and will describe any deficiencies that affect the protectiveness of the remedy and efforts taken, if any, to correct these deficiencies.

The base instruction will apply to all personnel at SUBASE Bangor, including contractors and tenants, and all activities that will affect the institutional controls or the remedial actions selected for the site. The base instructions will include the following:

- The conditions and boundaries of sites subject to land use control, as well as the terms and conditions of the land use control, shall be recorded on appropriate installation master plans, and base instructions for maintaining institutional controls.

- A point of contact for implementing, maintaining, and monitoring institutional controls.

If a change in land use or activity subject to in-place land use control is being considered, the regulatory agency shall be notified as soon as possible, in order to allow sufficient time for regulatory review and modifications to remedy selection, design, or implementation decision documents. The notification will include:

1) An evaluation of the risks to human health and the environment posed by the land use change and overall impact on remedy effectiveness;

2) An evaluation of the need for any additional remedial action resulting from the anticipated land use changes; and,

3) A proposal for any necessary changes in the selected remedial action

The following are considered changes in land use or activity affecting land use controls:

1) A change in land use or activity that is inconsistent with the exposure assumptions in the human health or ecological risk assessment that was the basis for the land use change (e.g., changes from industrial, commercial or recreational use to a more sensitive land use such as residential or day-care areas).

A change in land use or activity that would allow activity that is prohibited under the existing ROD or would degrade the remedy.

3) A change in land use that would require additional remediation before the new use could begin.

- A requirement that the Navy notify EPA and Ecology as soon as possible but no later than 60 days prior to any transfer, sale, or lease of property subject to institutional controls. The notification process is intended so that the parties can ensure that appropriate provisions are included in conveyance documents to maintain institutional controls.

- A requirement that the Navy coordinate with EPA and Ecology any proposed deletion or termination of an institutional control. Any disagreement between the parties will be resolved in accordance with the Federal Facility Agreement.

A requirement that the Navy promptly notify EPA and Ecology upon discovery of an activity that is inconsistent with the objectives described in this ROD, or that will cause a significant loss of protection of human health or the environment. The notification process is intended to allow the parties to identify any specific deficiencies in the institutional control process and for the Navy to implement corrections to prevent similar deficiencies in the future.

The base instruction does not create legal rights in any person or entity. However, this does not affect the enforceability of the institutional controls in this ROD.

Institutional Control will be administered by the federal government while it owns the property. Absent further cleanup at a particular OU, in the event of transfer of the property, it will be necessary to include deed or land use restrictions to implement the institutional controls. Deed restrictions cannot be placed on the property until transfer of the property. Upon transfer of the property, notification of the history of the site will be attached to any property transfer, which would have to meet the requirements of CERCLA Section 120(h).

Pursuant to Section 120(h)(1) of CERCLA and Part 373 of the NCP, should the United States enter into a contract for the sale or other transfer of SUBASE Bangor property, the United States would give notice of hazardous substances that have been stored, disposed of, or released on the property. Pursuant to Section 120(h)(3) of CERCLA, the United States would include in each deed entered into for the transfer of the property a covenant stating that the remedial action(s) are completed and any additional remedial action found to be necessary after the transfer shall be conducted by the United States. In addition to the covenants required by Section 120(h) of CERCLA, the Navy is seeking General Services Administration (GSA) approval of restrictive covenants/deed restrictions that will be included in the conveyance document to effectuate the ROD in the event of transfer of the property to a non-federal entity. The conveyance document shall require the non-federal transferee to record the restrictive covenants/deed restrictions with the county auditor within 30 days of transfer. Such covenants/deed restrictions will address any limits to remain in effect after the time of transfer to restrict land use, restrict the use of groundwater, and manage excavation. The deed covenants will also include provisions addressing the continued operation, maintenance, and monitoring of the selected remedy. In the event that GSA does not approve the restrictive covenants/deed restrictions prior to the land transfer, EPA or the state may reopen the ROD, or request an ESD to the ROD that originally established the institutional controls that are being made part of a private land deed.

11.9 EXPECTED OUTCOMES OF THE SELECTED REMEDY

The goal of the selected remedy is to protect human health by restoring the off-base groundwater to its primary use as a domestic drinking water source, and to eventually restore the overall site-

wide groundwater to acceptable quality standards as identified in the Washington State MTCA regulations.

The selected remedy has the goal of restoring OU 8 groundwater to residential use. The concentrations of VOCs in groundwater will be addressed through natural attenuation. The LNAPL beneath the PWIA will be removed through a free-product recovery system. The human health risks will be reduced to the acceptable range by achieving the cleanup levels. Benzene and DCA generally accounts for the majority of the risk from VOCs in groundwater. Once cleanup standards are achieved, Kitsap County Health Department administers the future use of local groundwater and has the authority to designate the groundwater as safe for human consumption and for granting use permits and/or approvals.

11.10 SUMMARY OF THE ESTIMATED REMEDY COSTS

The information in Table 10-1 is based on the best available information regarding the anticipated scope of the remedial alternatives. Changes in the cost elements are likely to occur as a result of new information and data collected during the on-going groundwater monitoring program. Major changes may be documented either in the form of a memorandum in the administrative record file, an Explanation of Significant Differences, or a ROD amendment depending on the significance of the change. The Navy's remedy cost estimates are order of magnitude engineering cost estimates expected to be within –30 to +50 percent of the actual project cost. The Navy's selected remedy for OU 8 requires $1.8 million over ten years to monitor natural attenuation processes and five years to operate the free-product recovery system. A detailed cost estimate for institutional control is provided in Tables 11-1 and 11-2. A detailed cost estimate for monitored natural attenuation is provided in Tables 11-3 and 11-4. A detailed cost estimate for free-product recovery is provided in Tables 11-5 and 11-6.

The estimated cost for free-product recovery is $120,000 in capital cost and $330,000 for five years of O&M, for a total of $450,000. This cost estimate assumes that five pneumatic free-product recovery systems will be installed in existing wells. Capital costs include site mobilization, free-product recovery systems and associated piping, and replacement of pumps and air compressors. The O&M costs include labor, disposal of LNAPL, performance reporting, personal protective equipment, and system installation.

The estimated cost for monitoring natural attenuation is $5,000 in capital cost and $965,000 for ten years of O&M, for a total of $970,000. This cost estimate assumes that natural attenuation will be monitored for ten years. Capital costs include sampling and analysis plan. The O&M costs include labor, groundwater samples analysis, disposal of purge groundwater, and performance reports.

The estimated cost for institutional control is $37,000 in capital cost and $333,000 for ten years of O&M, for a total of $370,000. This cost estimate assumes that institutional controls will be implemented for ten years. Capital costs include legal fees, wells abandonment, warning signs and fencing. The O&M costs include labor and replacement cost for warning signs and fence.

Summary of the Estimated Costs of the Selected Remedy

Specific cost estimates for the future implementation of the selected remedy at OU 8 are provided in Appendix C of the Final Feasibility Study. The costs are summarized here as $1,800,000 per ten-year period (see Table 10-1).

12. STATUTORY DETERMINATIONS

Under CERCLA Section 121 and the NCP, the Navy must select remedies that are protective of human health and the environment, comply with ARARs (unless a statutory waiver is justified), are cost effective, and utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. In addition, CERCLA includes a preference for remedies that employ treatment that permanently and significantly reduce the volume, toxicity, or mobility of hazardous substances as a principal element and a bias against off-site disposal of untreated wastes. The following sections discuss how the Selected Remedy meets these statutory requirements.

12.1 PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

The selected remedy, Alternative 4, will protect human health and the environment through the reduction of VOC contaminants in groundwater by natural attenuation. The principal threat material (LNAPL beneath the PWIA) will be removed through FPR. Current information suggests that natural attenuation is occurring at OU 8 and will cleanup the off-base groundwater to the drinking water standards by the year 2008. Specifically, the selected remedy will:

- Reduce risk by reducing the concentration of contaminants in the groundwater to levels below the cleanup levels.
- Prevent the use of contaminated groundwater.
- Provide for monitoring of groundwater to identify potential future risks associated with OU 8 and monitor the effectiveness of natural attenuation.

12.2 COMPLIANCE WITH ARARs

The selected remedy will be designed and implemented to comply with all action specific, chemical specific, and location specific ARARs identified in this section. The ARARs for OU 8 are presented below.

Chemical-Specific ARARs

- Safe Drinking Water Act (SDWA), 40 CFR Part 141, Maximum Contaminant Levels (MCLs) for public drinking water supplies are relevant and appropriate regulation for establishing organic and inorganic concentrations in groundwater aquifers potentially used for drinking water.
- Model Toxics Control Act (MTCA) Cleanup Regulation, Chapter 173-340 WAC, Method B risk-based cleanup levels are applicable for establishing groundwater cleanup levels.

Action-Specific ARARs

- Hazardous Materials Transportation Act is the applicable federal regulation for transportation of potentially hazardous material, including groundwater samples, purge groundwater, and recovered LNAPL.

- Minimum Standards for Construction and Maintenance of Wells (Chapter 173-160 and 162 WAC) are applicable state regulations for the location, design, construction, and abandonment of water supply and resource protection wells.

- Resource Conservation and Recovery Act (RCRA), is the applicable federal regulation for establishing standards for generators or hazardous wastes for the transportation of hazardous wastes including soil-cutting and LNAPL recovery.

- State of Washington Dangerous Waste Regulations (Chapter 173-303 WAC), are the applicable state regulations for handling and disposal of dangerous and hazardous wastes.

Location-Specific ARARs

- There are no identified location-specific ARARs.

12.3 COST-EFFECTIVENESS

The selected remedy is cost-effective and represents a reasonable value for the money spent. In making this determination, the following definition was used: "A remedy shall be cost-effective if its costs are proportional to its overall effectiveness" (NCP Section 300.430[f][1][ii][D]). This was accomplished by evaluating the "overall effectiveness" of those alternatives that satisfied the threshold criteria (protective of human health and the environment and ARAR-compliant). Overall effectiveness was evaluated by assessing three of the five balancing criteria in combination (long-term effectiveness and permanence; reduction in toxicity, mobility and volume through treatment; and short-term effectiveness). Overall effectiveness of this selected remedy was determined to be proportional to its cost and hence this alternative represents a reasonable value for the money to be spent.

The estimated present worth cost of Alternative 4 is $1,800,000, and is the least costly of all alternatives evaluated that meet the threshold criteria. The Navy believes that MNA and FPR will allow the migration of VOCs in groundwater to be controlled, thus removing the principal threat at OU 8. This selected remedy is expected to be cost effective as long as natural attenuation is occurring and concentrations continue to decline.

12.4 UTILIZATION OF PERMANENT SOLUTIONS AND ALTERNATIVE TREATMENT (OR RESOURCE RECOVERY) TECHNOLOGIES TO THE MAXIMUM EXTENT PRACTICABLE

The Navy has determined that the selected remedy represents the maximum extent to which permanent solutions and treatment technologies can be utilized in a practicable manner at OU 8. Of those alternatives that are protective of human health and the environment and comply with ARARs, the Navy has determined that the selected remedy provides the best balance of trade-offs in terms of the five balancing criteria. The Navy has also considered the statutory preference for treatment as a principal element and a bias against off-site treatment and disposal and considered state and community acceptance.

Alternative 4, provides a permanent solution to exposure to contaminated groundwater by removing the principal threat, reducing groundwater contaminants, and preventing unauthorized use of contaminated groundwater until the cleanup levels are met. Natural attenuation will reduce the concentrations of contaminants to levels below the cleanup levels. An alternate water supply has been provided to Mountain View Road resident to remove risks until the groundwater quality meets the drinking water standards.

Alternative 4 is the most effective in the long term due to simpler operating requirements of the remedial action as compared to other alternatives. Alternative 4 uses proven technologies that increase the reliability in reducing contaminant toxicity, mobility, and volume through treatment. This alternative includes measures to address short-term risk to nearby residents. The existing P&T system or an RM system can be implemented if natural attenuation does not clean up the groundwater in a reasonable time frame. Alternative 4 is the most cost effective alternative.

Ecology has been involved with the remedial investigation and remedy selection process. Concerns regarding the development of the alternatives were identified by Ecology and were adequately addressed. Ecology accepts the use of the selected alternative.

The community did not object to the use of Alternative 4, MNA+FPR+IC, at OU 8. The selected alternative provides for enough flexibility to address any additional concerns during O&M of the remedial action.

A five-year review of the selected remedy will be performed in accordance with the NCP. The review will be conducted as part of the SUBASE-wide reviews no less then every five years after the signing of the ROD to ensure the remedy continues to provide adequate protection of human health and the environment.

12.5 REFERENCE FOR TREATMENT AS A PRINCIPAL ELEMENT

The selected remedy includes as its principal element removal of the principal threat (LNAPL) and the reduction of groundwater contaminant mass through a destructive process. The selected remedy utilizes natural attenuation for the following reasons:

- The two-phase natural attenuation study indicates that natural attenuation is occurring and that groundwater at OU 8 provides favorable conditions for continued natural attenuation.

- An alternate water supply is being provided to Mountain View Road residents whose water supply has been impacted by VOCs.

12.6 FIVE-YEAR REVIEW REQUIREMENTS

Because the selected remedy will result in contaminants remaining in OU 8 groundwater at concentrations above levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted within five years of remedial action to ensure that the remedy is, or will be, protective of human health and the environment.

13. DOCUMENTATION OF SIGNIFICANT CHANGES

The Proposed Plan for OU 8 was released for public comment in May 2000. The Proposed Plan identified Alternative 4 (MNA+FPR+IC) as the preferred alternative for OU 8 groundwater remediation. This alternative reduces the potential for exposure to contaminated groundwater through the use of natural attenuation, source removal, and institutional controls. The Navy and Ecology have reviewed all written and verbal comments submitted during the public comment period. It was determined that no significant changes to the remedy, as originally identified in the Proposed Plan, were necessary.

14. RESPONSIVENESS SUMMARY

The Navy, together with the U.S. EPA and Washington State Department of Ecology (Ecology) presented the Proposed Plan for Remedial Action at OU 8 to the public during a Public Meeting held on May 16, 2000. Between May 12 and June 13, 2000, the Navy accepted comments on the Proposed Plan. During this comment period, a total of three comments were received. Each is presented below, along with the Navy's response.

COMMENT 1. I understand there were some payouts made to the neighbors as settling their claims on some of the things. Is that list available?

RESPONSE: This question was posed verbally at the Public Meeting as well as in writing. After some research into the matter, the Navy responded to the commentor by phone on May 25, 2000 with the following: Four claims have been filed under the Federal Tort Claims Act and these claims are pending.

COMMENT 2. What can be done for the orange residue in the water closet and dishwasher?

RESPONSE: The discoloration you observe is most likely due to iron in the water, something that is unrelated to the OU 8 site. The source of this iron can be the water, or the piping conveying it. The Navy recommends that you contact your water supplier, the Silverdale Water District, to learn what can be done to address this issue, such as faucet filters, etc. The Silverdale Water District's General Manager is Mr. Morgan Johnson and his phone number is (360) 692-2604.

COMMENT 3. Water pressure at the tap drops off to low after the water runs for about a quart.

RESPONSE: Similar to Comment 2, this issue is again unrelated to the OU 8 site and something that may be addressed with the water supplier who's name is given above. The low pressure may be attributable to the water pressure supplied from your service connection, your in-house plumbing, or a combination of the two.

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Tables

Tables

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Table 5-1. Geologic and Hydrogeologic Units of Kitsap County, Washington.

Construction Fill
• At OU 8, widely distributed throughout the Public Works Industrial Area to depths of three feet. • Locally present to depths of 10 to 15 feet • Present beneath roadways and parking surfaces.
Holocene Sediments
• At OU 8, includes thin layers of silt, sand and gravel in branches of Clear Creek. • Includes recent stream, lake, swamp and beach deposits. • Localized, thin layers of sand, gravel, silt or peat. • Variable permeability, and of little importance as an aquifer.
Vashon Recessional Outwash (Qvr)
• Not present at OU 8. • Glacial meltwater deposits of variable thickness, but up to 100 feet. • Discontinuous, unconsolidated deposits of sand, gravel, cobbles and silt. • Locally produces small quantities of perched groundwater.
Vashon Till (Qvt)
• Predominant surface deposit at OU 8, up to 40 feet thick. Generally unsaturated. • Regionally widespread unit up to 100 feet in thickness. • Typically a very dense mixture of sand, gravel, silt, and cobbles. • Low hydraulic conductivities in 10^{-5} to 10^{-6} cm/sec range. Higher where weathered as at OU 8.
Vashon Advance Outwash (Qva) ! "Shallow Aquifer"
• Focus of the OU 8 RI/FS. Typically 100 feet of coarsening upward sandy silt to sandy gravel. • Hosts regionally extensive shallow, unconfined aquifer system. • At OU 8, Qva thins to east, and is locally absent beneath the main branch of Clear Creek. • Hydraulic conductivities in 10^{-3} to 1 cm/sec range. Specific yields range from 3 to 20 percent. • Where saturated, yields moderately large quantities of water. • Lower contact with Lawton Clay is gradational over several tens of feet • Also referred to as Esperance Sand.
Lawton clay
• Forms lower bounding aquitard with the Qva aquifer. • Typically 40 to 80 feet thick, but up to 200 feet thick. • Low hydraulic conductivities in the 10^{-7} to 10^{-8} cm/sec range. • Where outcrops, springs and seeps common at upper contact with Qva. • Lowest stratigraphic unit investigated at OU 8
Possession Drift
• Heterogeneous mixture of till and outwash deposits. • Discontinuous across SUBASE Bangor.
Kitsap Formation
• Typically 70 to 150 feet thick, but up to 300 feet. • Nonglacial fluvial and lacustrine deposits consisting of sand, gravel, silt and clay. • Middle member consists of dense silt, clay and peat occurring at or near sea level forming regional aquitard. • Regionally extensive stratigraphic unit. • Also referred to as the Clover Park, Devils Hole, or Whidbey Formation.
Salmon Springs Drift
• Host to regional extensive, deep water supply aquifer. • Variable lithology: sand, gravel, silt and clay. • Up to 300 feet in thickness.
Early Pleistocene Deposits (Undifferentiated)
• Glacial and interglacial deposits up to 400 feet thick. • Consists mostly of silt and clay, with interbedded sands and gravels. • Forms basal confining stratigraphic unit for Quaternary aquifer systems.
Tertiary Bedrock
• Generally dark colored, fine grain basalts and other volcanic rocks. • Total thickness unknown, but greater than 7,000 feet.

Table 5-2. Physical Properties of the Shallow Aquifer.

Description	Result	Unit
Transmissivity (T)	6,720	ft^2/day
Hydraulic conductivity (K)	67	ft/day
Specific yield	0.6!8.4	Percent
Porosity (average)	34	Percent
Effective porosity	20	Percent
Pore velocity	1.5 550	ft/day ft/year

Note: Hydraulic conductivity was calculated based on aquifer thickness of 100 feet.

Table 5-3. OU 8 Sampling Rationale by Location. Part 1 of 2

Location	Sample Types	Analysis	Rationale
Source Area Identification			
8MW38	Soil Soil Gas Groundwater	VOC, SVOC	Location of former paint shop at Building 462. Spray guns were reportedly cleaned out using solvents. Trichloroethene (TCE) was detected in soil vapor just east of building, but no other sampling was conducted at this location.
8MW39	Soil Soil Gas Groundwater	VOC, SVOC	Northeast corner of Building 1026 (maintenance shop) where elevated concentration of chlorinated VOC were previously detected in soil vapor, and dumping of paint and solvents allegedly occurred in the past.
8MW40	Soil Soil Gas Groundwater	VOC, SVOC	East side of Building 1026 where elevated concentrations of chlorinated VOC were previously detected in soil vapor, and dumping of paint and solvent allegedly occurred in the past.
8MW41	Soil Soil Gas Groundwater	VOC, SVOC	Northeast end of Building 1014 where elevated concentrations of chlorinated VOC were previously detected in soil vapor, and traces of PCE were detected in Site 27 soils. Solvents were previously used and stored in Building 1014, and some were reportedly dumped in the gravel-lined steam cleaning pit.
8MW42	Soil Soil Gas Groundwater	VOC, SVOC	Between Buildings 1014 and 1203 where elevated concentrations of chlorinated VOC were previously detected in soil vapor, and trace levels of PCE were detected in Site 27 soils. Solvents were previously used and stored in Building 1014, and some were reportedly dumped in the gravel lined steam cleaning pit.
8MW43	Soil Soil Gas Groundwater	VOC, SVOC	Located just off the southwest corner of Building 1014 where low concentrations of tetrachloroethene (PCE) were detected in soil vapor. Solvents were previously used and stored in Building 1014.
8MW44	Soil Soil Gas Groundwater	VOC, SVOC	Location of former Building 665 where chlorinated solvents were used and stored, and steam cleaning operations took place. Previous soil vapor survey did not investigate this area.
8MW45	Soil Soil Gas Groundwater	VOC, SVOC	North end of former Building 15 (powerhouse/voltage shop). A train reportedly crashed into the building demolishing two drums of TCA. Previous soil vapor studies did not investigate this area.
8MW46	Soil Soil Gas Groundwater	VOC, SVOC	Located immediately south of Building 1268 where paints, solvents, and pesticides were previously stored. Previous soil vapor survey did not investigate this area.
8MW47	Soil Soil Gas Groundwater	VOC, SVOC	Just north of Building 1021 where solvents were previously used and stored. Low concentrations of 1,1,1-trichloroethane (TCA) were previously detected in soil vapor.
8MW48	Soil Soil Gas Groundwater	VOC, SVOC	South of Building 1202, and immediately adjacent to the former waste oil UST. Previous investigations have detected elevated concentrations of chlorinated VOC in soil vapor, and TPH in soil at 24,000 ppm. Paints and solvents were formerly stored in this building.
8MW49	Soil Soil Gas Groundwater	VOC, SVOC	Location of former Building 262, open storage for empty drums. Previous soil vapor survey did not investigate this area.
VS6 VS9	Soil Gas	VOC	Location of former paint shop, Building 1032. Previous investigation at Site 28 detected trace levels of PCE in soil. 1995 soil gas survey did not investigate this area, and existing vapor wells connected to petroleum remediation system not sampled for chlorinated VOCs.
VS11	Soil Gas	VOC	Vicinity of abandoned UST east of Building 1038, and former underground fuel vault (Building 18). Existing vapor wells connected to petroleum remediation system not sampled for chlorinated VOCs, and 1995 soil gas survey did not investigate this area.

Table 5-3. OU 8 Sampling Rationale by Location. Part 2 of 2

Location	Sample Types	Analysis	Rationale
VS13	Soil Gas	VOC	Vicinity of former underground fuel vault (Building 18). Existing vapor wells connected to petroleum remediation system not sampled for chlorinated VOC, and 1995 soil gas survey did not investigate this area.
VS16	Soil Gas	VOC	Former location of paint shop (Building 17). Existing vapor wells connected to petroleum remediation system not sampled for chlorinated VOC, and 1995 soil gas survey did not investigate this area.
MW03 MW04 MW05 MW07	Soil Gas	VOC	These 4 existing wells have screen above the water table that permit the collection of soil gas samples. These locations were either outside the area of the 1995 soil gas survey (MW07), were not completely investigated (MW03 & MW04) or contained elected concentrations of chlorinated VOC in soil gas (MW05).
Assess Vertical Extent of VOC and Characterize Lawton Clay			
8MW50	Soil Groundwater	VOC SVOC	Deep monitoring well in center of Public Works Industrial Area to complement existing shallow and intermediate completions (8MW06 and 7). Define vertical extent of VOC in groundwater using Hydropunch® method. Determine depth and hydraulic conductivity of Lawton Clay.
Monitor Eastern Margin of OU 8			
8MW51	Soil Groundwater	VOC SVOC	Monitor intermediate depth groundwater cast of Clear Creek Road.
8MW52	Soil Groundwater	VOC SVOC	Monitor deep groundwater east of Clear Creek Road.
Assess Current Extent of VOC			
All Existing Wells	Groundwater (All OU 8 Wells)	VOC SVOC	Complete round of groundwater monitoring to determine the current extent and concentration of the groundwater contamination plume.
Collect Additional Data to Support Risk Assessment			
SP1 SP2 SP3	Groundwater seep Sediment	VOC SVOC	Evaluate the presence or absence of exposure pathway in Clear Creek.

Key:
VOC Volatile Organic Compounds by EPA Modified Method 8260 (includes acetone). Soil vapor by EPA Method TO-14.
SVOC Semivolatile Organic Compounds by Modified Method 8270 (includes bromacil and heptachlor epoxide)
[1] Six existing wells at OU 8 were sampled for SVOC: 8MW01, 8MW03, 8MW06, 8MW13, 8MW24, and 25MW01.

Additional Notes:
- Selected soil samples were tested for grain size, bulk density, porosity, hydraulic conductivity (Lawton Clay only), total organic carbon, ion exchange capacity and redox potential to support fate and transport modeling and remedial design.
- Selected groundwater samples were tested for total dissolved solids, hardness, Langelier index, and total organic carbon to support fate and transport modeling and remedial design.
- All groundwater samples were field tested for pH, turbidity, temperature, dissolved oxygen, and conductivity.

Table 5-4. VOC and SVOC Detections in Subsurface Soil Samples and Screening Levels (from RI Report, 1999)

VOC	Number of Analyses	Number of Detects	Detected Concentration (µg/kg)		MTCA B Screening Levels (µg/kg)	Maximum Detected Location	
			Minimum	Maximum		Well	Depth (ft)
VOC							
1,2,4-Trimethylbenzene	28	9	4	43,000	NA	8MW49	30
1,2-Dichloroethane (DCA)	28	1	11	11	11,000	8MW47	40
1,3,5-Trimethylbenzene	28	9	1	11000	NA	8MW49	30
Acetone	28	2	11	16	8,000,000	8MW49	35
Benzene[2]	28	3	24	460	345,000	8MW49	30
Ethylbenzene[2]	28	7	1	6,700	8,000,000	8MW49	30
Isopropylbenzene	28	3	1	1,100	3,200,000	8MW49	30
m-Xylene + p-Xylene	28	8	1	34	160,000,000	8MW49	25
n-Propylbenzene	28	6	2	4,300	NA	8MW49	30
Naphthalene[1]	28	8	7	11,000	3,200,000	8MW49	30
o-Xylene	28	8	1	14,000	160,000,000	8MW49	30
sec-Butylbenzene	28	2	5	640	NA	8MW49	30
Toluene[2]	28	8	1	12,000	16,000,000	8MW49	30
SVOC							
2-Metylynaphthalene[2]	24	6	140	2,400	NA	8MW49	30
Acenaphthene	24	1	650	650	NA	8MW38	35
Anthracene	24	2	330	620	24,000,000	8MW38	35
Benz(a)anthracene[2]	24	1	**230**	**230**	0.012	8MW38	35
Benzo(a)pyrene[2]	24	1	**120**	**120**	0.012	8MW38	35
Benzo(b)fluoranthene[2]	24	1	**150**	**150**	0.012	8MW38	35
Benzoic acid	24	1	660	660	320,000,000	8MW41	15
Bis(2-Ethylhexyl)phthalate[2]	24	1	140	140	71.4	8MW46	30
Chrysene[2]	24	2	**120**	**290**	0.012	8MW38	35
Dibenzofuran	24	1	380	380	NA	8MW38	35
Fluoranthene	24	1	930	930	3,200,000	8MW38	35
Fluorene	24	1	540	540	3,200,000	8MW38	35
Naphthalene[1]	24	1	1,500	1,500	3,200,000	8MW38	35
Phenanthrene	24	1	1,800	1,800	NA	8MW38	35
Pyrene	24	2	720	750	2,400,000	8MW42	5

Notes: Sample concentrations and MTCA levels shown in µg/kg.
Concentrations exceeding MTCA B levels shown in bold face.
Samples analyzed by Modified EPA Method 8270.
NA ! MTCA B value not available for either soil or groundwater.
[1] Napthalene appears on both the 8260 and 8270 list of target compounds.
[2] Identified COPC for on-base subsurface soil.

Table 5-5. VOC Detections in Groundwater Samples and Screening Levels (from RI Report, 1999) **Part 1 of 2**

VOC	Number of Analyses	Number of Detects	Detected Concentration (Fg/L)		MTCA B Screening Levels (Fg/L)	Maximum Detected Location	
			Minimum	Maximum		Well	Groundwater Zone
Public Works Industrial Area							
1,1,1-Trichloroethane	37	12	0.3	10	7,200	8MW24, 8MW30, 8MW40 & 8MW49	S
1,1,2-Trichloroethane[2]	37	4	**3**	**24**	0.768	8MW33	S
1,1-dichloroethane	37	3	2	8	800	MW03 & MW48	S
1,1-Dichloroethene[2] (DCE)	37	2	**3**	**8**	0.0729	MW04 & 8MW33	S
1,2,4-Trimethylbenzene	37	13	0.4	2,800	NA	8MW04	S
1,2-Dibromoethane[2] (EDB)	37	5	**11**	**300**	0.00515	8MW49	S
1,2-Dichloroethane[2] (DCA)	37	8	**0.9**	**990**	0.481	8MW24	S
1,2-Dichloropropane[2]	37	2	**3**	**6**	0.643	8MW33	S
1,3,5-Trimethylbenzene	37	12	2	620	NA	MW04	S
2-Chlorotoluene	37	1	51	51	NA	MW08	S
Benzene[2]	36	13	0.4	**9,800**	1.51	8MW49	S
Carbon tetrachloride[2]	11	1	3	**3**	0.337	8MW31	I
Chloroform[2]	37	9	0.4	3	7.17	8MW42	S
cis-1,2-Dichloroethene	37	2	0.5	4	80	MW04 & 8MW42	S
Ethylbenzene[2]	37	12	10	**1,600**	800	8MW30	S
Isopropylbenzene[2]	37	12	3	60	640	8MW30	S
Isopropyltoluene	37	2	4	16	NA	MW05	S
M-Xylene + p-Xylene[2]	37	12	13	7,700	16,000	MW04	S
N-Propylbenzene[2]	37	10	0.2	150	NA	28MW01	S
Naphthalene [1,2]	37	12	3	**690**	320	8MW49	S
o-Xylene[2]	37	12	4	3,600	16,000	MW04	S
sec-Butylbenzene	37	1	0.6	0.6	NA	MW03	D
tert-Butylbenzene	37	1	49	49	NA	MW08	S
Tetrachloroethene	37	1	0.7	0.7	0.858	MW09	S
Toluene[2]	37	12	21	**18,000**	1600	8MW47	S
Trichloroethene[2]	37	1	7	7	3.98	8MW39	S

Table 5-5. VOC Detections in Groundwater Samples and Screening Levels (from RI Report, 1999) **Part 2 of 2**

VOC	Number of Analyses	Number of Detects	Detected Concentration (Fg/L)		MTCA B Screening Levels (Fg/L)	Maximum Detected Location	
SUBASE Boundary							
1,1,2-Trichloroethane[2]	4	3	**6**	**10**	0.768	8MW03	I
1,1-Dichloroethane	4	1	0.6	0.6	800	8MW01	I
1,1-Dichloroethene[2] (DCE)	4	3	2	**4**	0.0729	8MW03	I
1,2-Dichloroethane[2] (DCA)	4	3	**100**	**300**	0.481	8MW03	I
1,2-Dichloropropane[2]	4	2	2	**5**	0.643	8MW03	I
Benzene[2]	4	3	0.9	**60**	1.51	8MW03	I
Isopropylbenzene[2]	4	1	0.5	0.5	640	8MW03	I
Mountain View Residential Area							
1,1,2-Trichloroethane[2]	5	1	**35**	**35**	0.768	8MW13	I
1,1-Dichlorethene[2] (DCE)	5	1	**13**	**13**	0.0729	8MW13	I
1,2,4-Trimethylbezene	5	1	0.6	0.6	NA	8MW13	I
1,2-Dichloroethane2 (DCA)	5	1	**340**	**340**	0.481	8MW13	I
1,2-Dichloropropane[2]	5	1	**15**	**15**	0.643	8MW13	I
Benzene [2]	5	1	**130**	**130**	1.51	8MW13	I
Carbon tetrachloride	5	1	**2**	**2**	0.337	8MW19	I

Notes:

Concentrations exceeding MTCA B Levels shown in bold face

S = shallow aquifer depth, I = intermediate aquifer depth, D = deep aquifer depth.

NA - MTCA B value not available for either soil or groundwater

1 Napthalene appears on both the VOC and SVOCs list of compounds

2 Identified as COPC in groundwater

Table 5-6. SVOC Detections in Groundwater Samples and Screening Levels (from RI Report, 1999)

SVOC	Number of Analyses	Number of Detects	Detected Concentration (Fg/L)		MTCA B Screening Levels (Fg/L)	Max Detected Location	
			Minimum	Maximum		Well	Groundwater Zone
Public Works Industrial Area							
2-Chlorophenol	19	1	4	4	80	8MW39	S
2-Methylnaphthalene[2]	19	4	20	160	NA	8MW49	S
2-Methlphenol[2]	19	2	40	81	800	8MW47	S
4-Chloro-3-methylphenol	19	1	6	6	NA	8MW39	S
4-Methylphenol[2]	19	2	9	73	80	8MW47	S
Acenaphthene	19	1	3	3	960	8MW39	S
Benzoic acid	19	3	25	66	64,000	8MW48	S
Bromacil[2]	19	1	30	30	901	8MW48	S
Phenol	19	4	4	35	9,600	8MW47	S
Pyrene	19	1	3	3	480	8MW39	S
SUBASE Boundary							
bis(2-Chloroethyl)ether[2]	3	1	4	4	320	8MW03	I
bis(2-Ethylhexyl)phthalate[2]	3	1	3	3	6.25	8MW01	I
Bromacil[2]	3	2	13	30	901	8MW03	I
Mountain View Residential Area							
bis(2-Chloroethyl)ether[2]	4	1	8	8	320	8MW13	I

Notes:
NA - MTCA B value not available for either soil or groundwater.
[1]EPA health advisory for long term exposure.
[2]Identified as COPC in groundwater.
Concentrations exceeding MTCA B Levels shown in bold face, no exceedances in Table 5-6.

Table 5-7. VOC and SVOC Detections in Groundwater Seep and Sediment Samples and Screening Levels(from RI Report, 1999)

Location	Matrix	Chemical	Concentration (ppb)	MTCA Method B Screening Levels (ppb)
Volatile Organic Compounds				
SP1	Groundwater Seep	Toluene	9	1,600
SP1	Sediment	Toluene	74	16,000,000
SP3	Sediment	Toluene	90	16,000,000
SP3	Sediment	Acetone	350	8,000,000
Semivolatile Organic Compounds				
SP1	Groundwater Seep	Di-n-octylphthalate	10	NA
SP1	Groundwater Seep	bis(2-Ethylhexyl)phthalate	4 J	6.25
SP1	Groundwater Seep	Benzoic Acid	9	64,000
SP1	Sediment	4-Methylphenol	990	NA
SP2	Groundwater Seep	Benzoic Acid	7	64,000
SP3	Groundwater Seep	Benzoic Acid	3	64,000

Notes:
Concentrations shown in parts per billion (ppb). This is Fg/L for groundwater seep samples, and Fg/kg for sediment samples.
MTCA Method B cleanup levels are for groundwater and soil.

Table 5-8. Chemicals of Concern in OU 8 Groundwater and Chemical-Specific ARARs.

Chemical of Concern	Risk Assessment		SDWA MCLs[1] (ug/L)	MTCA Method B[2] (ug/L)
	1995/96[a]	1998/99[b]		
Benzene	U		5	1.51
1,2-Dibromoethane (EDB)	U		0.05	0.000515
1,2-Dichloroethane (DCA)	U	x	5	0.481
1,1-Dichloroethene (DCE)	U		7	0.0729
Toluene	U		1000	160
1,2,4-Trimethylbenzene	U		--	--
Bis(2-Chloroethyl)ether	U	x	--	0.0398
Bis(2-Ethylhexyl)phthalate	U		6	6.25
Naphthalene	U		--	320

Note:
a - 1995/96 risk assessment for site-wide groundwater.
b - 1998/99 risk assessment for off-base groundwater.
1 - Safe Drinking Water Act (SWDA), Maximum Contaminant Levels (MCLs).
2 - State of Washington Model Toxics; Control Act (MTCA), Method B values.
U - Human health risks to on-base residents.

x - Human health risks to off-base residents.

Table 5-9. Chemical Specific Risk Summary by Exposure Pathway and Receptor at OU 8 (Original Risk Assessment, 1995/96).

	Exposure Pathway													
	Ingestion of Groundwater		Dermal Contact with Groundwater		Inhalation during showering		Inhalation during Irrigation		Ingestion of Crops		Ingestion of Livestock		Risk by Aggregate Exposure Only	
Chemical of Concern	Cancer	Non-Cancer	Cancer	Non-Cancer	Cancer	Non-Cancer	Cancer	Non-Cancer	Cancer	Non-Cancer	Cancer	Non-Cancer	Cancer	Non-Cancer
Benzene	U	U k[1]	U	U	U	U k[1]		U[1]						k
1,2-Dibromoethane (EDB)	U				U									
1,2-Dichloroethane (DCA)	U				U									
1,2-Dichloroethene (DCE)													U	
Toluene		U		U[1]		U								
1,2,4-Trimethylbenzene				U[1]										
Bis(2-Chloroethyl)ether									U j k					
Bis(2-Ethylhexyl)phthalate											U j k	U j k		
Naphthalene										U[1]				

U- Future on-base residents (adults)
U[1]- Future on-base residents (children only)
j - Current off-base residents (adults)
k - Future off-base residents (adults)
k[1]- Future off-base residents, (children only)

Table 5-10. Chemical Specific Risk Summary for Future Off-Base Residents by Exposure Pathway at OU 8 (1998/99 Risk Assessment).

	Exposure Pathway													
	Ingestion of Groundwater		Dermal Contact with Groundwater		Inhalation during showering		Inhalation during Irrigation		Ingestion of Crops		Ingestion of Livestock		Risk by Aggregate Exposure Only	
Chemical of Concern	Cancer	Non-Cancer	Cancer	Non-Cancer	Cancer	Non-Cancer	Cancer	Non-Cancer	Cancer	Non-Cancer	Cancer	Non-Cancer	Cancer	Non-Cancer
Benzene														
1,2-Dibromoethane (EDB)														
1,2-Dichloroethane (DCA)														
1,2-Dichloroethene (DCE)														
Toluene														
1,2,4-Trimethylbenzene														
Bis(2-Chloroethyl)ether	k				k								k	
Bis(2-Ethylhexyl)phthalate														
Naphthalene														

k - Future off-base residents (adults)

Table 7-1. Chronic Toxicity Values for Noncarcinogenic Chemicals of Concern.

Chemical of Concern	Exposure Route	RfD (mg/kg-day)	Uncertainty Factor	Modifying Factor	Confidence Level	Target Organ	Critical Effect	Source
Benzene	Oral	$3x10^{-3}$	1000	3	medium	blood	cytopenia	STSC
	Inhalation	$1.7x10^{-3}$	--	--	--	--	--	EPA
	Dermal	$2.4x10^{-3}$	--	--	--	--	--	EPA
1,2-Dibromoethane (EDB)	Oral	NA	--	--	--	--	--	--
	Inhalation	$5.7x10^{-5}$	--	--	--	liver	hepatic effects	EPA
	Dermal	NA	--	--	--	--	--	--
1,2-Dichloroethane (DCA)	Oral	$3x10^{-2}$	1000	1	low	body and kidney	weight changes	STSC
	Inhalation	$1.4x10^{-3}$	--	--	--	--	--	CO
	Dermal	$2.4x10^{-2}$	--	--	--	--	--	CO
1,1-Dichloroethene (DCE)	Oral	$9x10^{-3}$	1000	1	medium	liver	hepatic lesions	EPA
	Inhalation	$9x10^{-3}$	--	--	--	--	--	CO
	Dermal	$7.2x10^{-3}$	--	--	--	--	--	CO
Toluene	Oral	$2x10^{-1}$	100	1	medium	liver	weight changes	EPA
	Inhalation	$1.1x10^{-1}$	100	3	medium	nervous system	neurobehavioral	EPA
	Dermal	$1.6x10^{-1}$	--	--	--	--	--	CO
1,2,4-Trimethylbenzene	Oral	$5x10^{-2}$	NA	NA	NA	NA	NA	EPA
	Inhalation	$5x10^{-2}$	--	--	--	--	--	CO
	Dermal	$4x10^{-2}$	--	--	--	--	--	CO
Bis(2-Chloroethyl)ether	Oral	NA	--	--	--	--	--	--
	Inhalation	NA	--	--	--	--	--	--
	Dermal	NA	--	--	--	--	--	--
Bis(2-Ethylhexyl)phthalate	Oral	$2x10^{-2}$	1000	1	medium	liver	increased weight	EPA
	Inhalation	$2x10^{-2}$	--	--	--	--	--	CO
	Dermal	$1x10^{-2}$	--	--	--	--	--	CO
Naphthalene	Oral	$1x10^{-2}$	--	--	--	--	--	--
	Inhalation	$1.1x10^{-2}$	--	--	--	lung	inflamation	NTP
	Dermal	$2x10^{-2}$	--	--	--	--	--	CI

CI - Extrapolated from chronic inhalation toxicity data.
CO - Extrapolated from chronic oral toxicity data.
EPA - U.S. Environmental Protection Agency.
NA - Toxicity value not currently available.
STSC - Superfund Technical Support Center Provisional Value.

Table 7-2. Toxicity Values for Carcinogenic Chemical of Concern.

Chemical of Concern	Carcinogenicity Category[1]	Exposure Route	Slope Factor $(mg/kg\text{-}day)^{-1}$	Target Organ	Critical Effect	Species	Exposure Route	Source
Benzene	A	Oral	$2.9x10^{-2}$	blood	luekemia	human	inhalation	EPA
		Inhalation	$2.9x10^{-2}$	blood	leukemia	human	inhalation	EPA
		Dermal[2]	$3.6x10^{-2}$	--	--	--	--	--
1,2-Dibromoethane (EDB)	B2	Oral	$8.5x10^{-1}$	stomach, liver, and blood	carcinomas	rat	ingestion	EPA
		Inhalation	$7.7x10^{-1}$	spleen and adrenal gland	tumors	rat	inhalation	EPA
		Dermal[2]	$1.1x10^{-2}$	--	--	--	--	--
1,2-Dichloroethane (DCA)	B2	Oral	$9.1x10^{-2}$	cardiovascular system	hemangio-sarcomas	rat	ingestion	EPA
		Inhalation	$9.1x10^{-2}$	circulatory system	sarcomas	rat	inhalation	EPA
		Dermal	$1.1x10^{-1}$	--	--	--	--	--
1,1-Dichloroethene (DCE)	C	Oral	$6x10^{-1}$	adrenal gland	tumors	rat	ingestion	EPA
		Inhalation	$1.7x10^{-1}$	kidney and mammary	carcinomas	mouse	inhalation	EPA
		Dermal[2]	$7.5x10^{-1}$	--	--	--	--	--
Toluene	--	Oral	--	--	--	--	--	--
		Inhalation	--	--	--	--	--	--
		Dermal[2]	--	--	--	--	--	--
1,2,4-Trimethylbenzene	--	Oral	--	--	--	--	--	--
		Inhalation	--	--	--	--	--	--
		Dermal	--	--	--	--	--	--
Bis(2-Chloroethyl)ether	B2	Oral	$1.1x10^{0}$	liver	tumors	mouse	ingestion	EPA
		Inhalation[2]	$1.2x10^{0}$	--	--	--	--	--
		Dermal[2]	$2.2x10^{0}$	--	--	-	--	--
Bis(2-Ethylhexyl)phthalate	B2	Oral	$1.4x10^{-2}$	liver	carcinomas and adenomas	rat and mouse	ingestion	EPA
		Inhalation[2]	$1.4x10^{-2}$	--	--	--	--	--
		Dermal[2]	$2.8x10^{-2}$	--	--	--	--	--
Naphthalene	--	Oral	--	--	--	--	--	--
		Inhalation	--	--	--	--	--	--
		Dermal	--	--	--	--	--	--

1 - EPA weight of evidence classification.
2 - Derived from chronic oral slope factor.
-- No data available.
EPA - U.S. Environmental Protection Agency.

Table 7-3. Potentially Complete Exposure pathways for Potential Receptor at OU 8.

Exposure Pathway	On-base Receptors		Off-base Receptors	
	Future Construction Workers	Future Residents	Current Residents	Future Residents
Incidental ingestion of subsurface soil	x	x		
Incidental ingestion of surface soil irrigated with contaminated groundwater			x	x
Dermal contact with subsurface soil	x	x		
Dermal contact with surface soil irrigated with contaminated groundwater			x	x
Inhalation of particulates from subsurface soil	x	x		
Inhalation of particulates from surface soil irrigated with contaminated groundwater			x	x
Inhalation of volatiles form subsurface soil	x	x		
Inhalation of volatiles form surface soil irrigated with contaminated groundwater			x	x
Ingestion of groundwater from a hypothetical well		x		x
Dermal contact with groundwater form a hypothetical well during bathing or showering		x		x
Inhalation of volatiles form groundwater from a hypothetical well during bathing or showering		x		x
Inhalation of volatiles from groundwater during soil irrigation		x	x	x
Ingestion of crops or other vegetation irrigated with contaminated groundwater		x	x	x
Ingestion of livestock and deer that consume crops and ingest soils irrigated with contaminated groundwater		x	x	x

Table 8-1. Cleanup Levels for Chemicals of Concern in Groundwater, SUBASE Bangor

Chemical of Concern[1]	CAS Number	Cleanup Level[2] (ug/L)	Reference Origin (MTCA Method B[3] vs MCL[4])
Benzene	71-43-2	5	MCL
1,2-Dibromoethane (EDB)	106-93-4	0.000515	MTCA Method B
1,2-Dichloroethane (DCA)	107-06-2	5	MCL
1,1-Dichloroethene (DCE)	75-35-4	0.0729	MTCA Method B
Toluene	108-88-3	1000	MCL

CAS - Chemical Abstract Service
1 - Chemical of Concerns were determined using the maximum detected concentrations during the 1999 groundwater sampling events.
2 - Per MTCA Cleanup Levels and Risk Calculation (CLARC II) February 1996 "Notes on MCL Table," MCLs are only usable as a cleanup standard if when used in the MTCA Method B equations, they result in risks that meet the MTCA standards of 1x10-5 excess cancer risk and hazard quotient (HQ) of 1.0.
3 - State of Washington Model Toxics Control Act (MTCA) Cleanup Regulation (WAC 173-340-720 [3])
4 - Maximum Contaminant Levels (MCLs) under promulgation of the Safe Drinking Water Act (SDWA)

Table 10-1. Summary of Present Value Costs for Remedial Alternatives.

Remedial Alternatives	Estimated Present Worth Cost
Alternative 1: No Action	
No Action	$230,000
Total	**$230,000**
Alternative 2: LTM+SVE(existing)+ P&T+LUC	
Land Use Controls	$370,000
Long Term Monitoring	$970,000
Soil Vapor Extraction (existing system)[1]	$700,000
Pump &Treat	$2,400,000
Total	**$4,400,000**
Alternative 3: MNA+RM+LUC	
Land Use controls	$370,000
Monitored Natural Attenuation	$970,000
Redox Manipulation	$910,000
Total	**$2,300,000**
Alternative 4: MNA+FPR+LUC	
Land Use Controls	$370,000
Monitored Natural Attenuation	$970,000
Free-Product Recovery[1]	$450,000
Total	**$1,800,000**
Alternative 5: MNA+SVE(expanded)+LUC	
Land Use Controls	$370,000
Monitored Natural Attenuation	$970,000
Soil Vapor Extraction 9expandeed system)[1]	$1,300,000
Total	**$2,600,000**
Alternative 6: LTM+FPR+SVE(expanded)+LUC	
Land Use Controls	$370,000
Long Term Monitoring	$970,000
Free-Product Recovery	$450,000
Soil Vapor Extraction (expanded system)[1]	$1,300,000
Total	**$3,100,000**

Notes:

Present worth cost over a 10-year period with annual inflation at 3% and interest at 5%.

1 - Present worth cost over 5 year operational period.

Table 11-1. Estimated Cost for Institutional Control (IC).

DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL COST
CAPITAL COSTS				
DIRECT CAPITAL COST	5	well	$800	$4,000
Off-base supply well decommissioning	1	ls	$800	$800
Warning signs and posts	1	ls	$3,000	$3,000
Fence				$7,800
Subtotal Direct Capital Cost				
INDIRECT CAPITAL COSTS				
Community meeting	1	ls	$4,000	$4,000
Legal fee	1	ls	$25,000	$25000
Subtotal Indirect Capital Cost				$29,000
TOTAL CAPITAL COSTS (rounded)				$37,000
OPERATING AND MAINTENANCE COSTS (12 months)				
Institutional control enforcement officer (40 hrs/month)	480	hr	$75	$36,000
Sign and fence replacement	1	ls	$500	$500
TOTAL O&M COSTS (rounded)				$37,000

Table 11-2. Present Worth Analysis for Institutional Control (IC).

Inflation 3%
Interest 5%

	Cost in Present Dollars									
	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**
Utilities	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Labor	$ 36,000	$ 36,000	$ 36,000	$ 36,000	$ 36,000	$ 36,000	$ 36,000	$ 36,000	$ 36,000	$ 36,000
ODCs	$ 4,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Reporting	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Analytical Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Equipment Maintenance	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500
Capital Costs	$ 33,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total	$ 73,500	$ 36,500	$ 36,500	$ 36,500	$ 36,500	$ 36,500	$ 36,500	$ 36,500	$ 36,500	$ 36,500
Annual Cost in Future Dollars	$ 73,500	$ 37,595	$ 38,723	$ 39,885	$ 41,081	$ 42,314	$ 43,583	$ 44,890	$ 46,237	$ 47,624
Present Value of Annual Cost	$ 73,500	$ 35,805	$ 35,123	$ 34,454	$ 33,797	$ 33,154	$ 32,522	$ 31,903	$ 31,295	$ 30,699

Total Present Value (rounded) $ **370,000**

Table 11-3. Estimated Cost for Monitored Natural Attenuation (MNA).

DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL COST
CAPITAL COSTS				
INDIRECT CAPITAL COSTS				
Site specific health and safety plan	1	ls	$1,000	$1,000
Sampling and analysis plan	1	ls	$4,000	$4,000
Subtotal Indirect Capital Cost				$5,000
TOTAL CAPITAL COSTS (rounded)				$5,000
OPERATION AND MAINTENANCE COSTS (12 months)				
Field labor (2 events, 3-person crew, 6 days/event, 8 hr/day)	288	hr	$45	$12,960
Field labor per diem (2 events, 3-person crew, 6 days/event)	36	day	$85	$3,060
RGA Rental (2 events, 6 days/event)	12	day	$121	$1,452
Field GC (2 events, 2 weeks/event)	4	week	$7,500	$30,000
Water Quality Meter Rental (2 events, 2 meters/event, 2 weeks/event)	8	Week	$1,000	$8,000
Laboratory Analysis (VOCs, 2 events, 25 wells/event)	50	analysis	$150	$7,500
Laboratory Analysis (Gen. Chem, 2 events, 25 wells/event)	50	analysis	$550	$27,500
Field vehicle (2events, 6 days/event)	12	day	$55	$600
Summary report	2	ls	$5,000	$10,000
TOTAL O&M COSTS (rounded)				$100,000

Table 11-4. Present Worth Analysis for Monitored Natural Attenuation (MNA).

Inflation 3%
Interest 5%

	Cost in Present Dollars									
	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**
Utilities	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Labor	$ 16,020	$ 16,020	$ 16,020	$ 16,020	$ 16,020	$ 16,020	$ 16,020	$ 16,020	$ 16,020	$ 16,020
ODCs	$ 45,112	$ 45,112	$ 45,112	$ 45,112	$ 45,112	$ 45,112	$ 45,112	$ 45,112	$ 45,112	$ 45,112
Reporting	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000
Analytical Costs	$ 35,000	$ 35,000	$ 35,000	$ 35,000	$ 35,000	$ 35,000	$ 35,000	$ 35,000	$ 35,000	$ 35,000
Equipment Maintenance	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Capital Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total	$ 106,132	$ 106,132	$ 106,132	$ 106,132	$ 106,132	$ 106,132	$ 106,132	$ 106,132	$ 106,132	$ 106,132
Annual Cost in Future Dollars	$ 106,132	$ 109,316	$ 112,595	$ 115,973	$ 119,453	$ 123,036	$ 126,727	$ 130,529	$ 134,445	$ 138,478
Present Value of Annual Cost	$ 106,132	$ 104,110	$ 102,127	$ 100,182	$ 98,274	$ 96,402	$ 94,566	$ 92,765	$ 90,998	$ 89,264

Total Present Value (rounded) $ 970,000

Table 11-5. Estimated Cost for Free-Product Recovery

DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL COST
CAPITAL COSTS				
DIRECT CAPITAL COST				
Extraction well drilling and completion	5	well	$4,500	$22,500
Air piping	650	ft	$3	$1,950
Return piping	650	ea	$5	$3,250
Asphalt cutting and disposal	1800	ft	$8	$14,400
Shallow trenching	400	ft	$8	$3,200
Air compressor	1	ea	$6,000	$6,000
Shallow conduit box and cover	900	ft	$20	$18,000
Free product recovery pump	2	ea	$2,500	$5,000
Valves	1	ls	$300	$300
Fitting	1	ls	$1,200	$1,200
Sol cutting disposal	1	ls	$3,000	$3,000
Storage shed	1	ea	$5,000	$5,000
Pumps/air compressor repair and replacement (year 3)	1	ls	$5,000	$5,000
Subtotal Direct Capital Cost				**$88,800**
INDIRECT CAPITAL COSTS				
Construction oversight (mid-level, 5 days)	40	hr	$60	$2,400
Personal protetive equipment	1	ls	$800	$800
Field vehicle	5	day	$55	$275
Traffic control (5 days, 8 hr/day)	40	hr	$35	$1,400
Site specific health and safety plan	1	ls	$500	$500
Engineering design (mid-level)	80	hr	$60	$4,800
Engineering design (senior-level)	24	hr	$95	$2,280
CADD	16	hr	$45	$720
Free product disposal (average 55 gal/month)	12	ls	$220	$2,640
Report production (graphic & word process)	1	ls	$1,500	$1,500
System startup	1	ls	$10,000	$10,000
Field labor (2-person crew)	5	day	$300	$1,500
O & M Manual	1	ls	$2,000	$2,000
Subtotal Indirect Capital Cost				$30,815
TOTAL CAPITAL COSTS (rounded)				**$120,000**
OPERATING AND MAINTENANCE COSTS (12 months)				
Field labor (system inspection and sample collection, 0.5 FTE)	1040	hr	$45	$46,800
Parts replacement budget	12	mo	$100	$1,200
Laboratory analysis (fingerprint, 2 events, 1 sample/event)	2	analysis	$500	$1,000
O & M report	4	ls	$2,500	$10,000
Sampling equipment	1	ls	$5,000	$5,000
Electricity	12	mo	$150	$1,800
TOTAL O & M COSTS (rounded)				**$66,000**

Table 11-6. Present Worth Analysis for Free-Product Recovery (FPR).

Inflation 3%
Interest 5%

	Cost in Present Dollars									
	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**
Utilities	$ 1,800	$ 1,800	$ 1,800	$ 1,800	$ 1,800	$ -	$ -	$ -	$ -	$ -
Labor	$ 46,800	$ 46,800	$ 46,800	$ 46,800	$ 46,800	$ -	$ -	$ -	$ -	$ -
ODCs	$ 7,640	$ 7,640	$ 7,640	$ 7,640	$ 7,640	$ -	$ -	$ -	$ -	$ -
Reporting	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ -	$ -	$ -	$ -	$ -
Analytical Costs	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ -	$ -	$ -	$ -	$ -
Equipment Maintenance	$ 1,200	$ 1,200	$ 1,200	$ 1,200	$ 1,200	$ -	$ -	$ -	$ -	$ -
Capital Costs	$ 115,000	$ -	$ 5,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total	$ 183,440	$ 68,440	$ 73,440	$ 68,440	$ 68,440	$ -	$ -	$ -	$ -	$ -
Annual Cost in Future Dollars	$ 183,440	$ 70,493	$ 77,912	$ 74,786	$ 77,030	$ -	$ -	$ -	$ -	$ -
Present Value of Annual Cost	$ 183440	$ 67,136	$ 70,669	$ 64,603	$ 63,373	$ -	$ -	$ -	$ -	$ -

Total Present Value (rounded) **$ 450,000**

Figures

Figures

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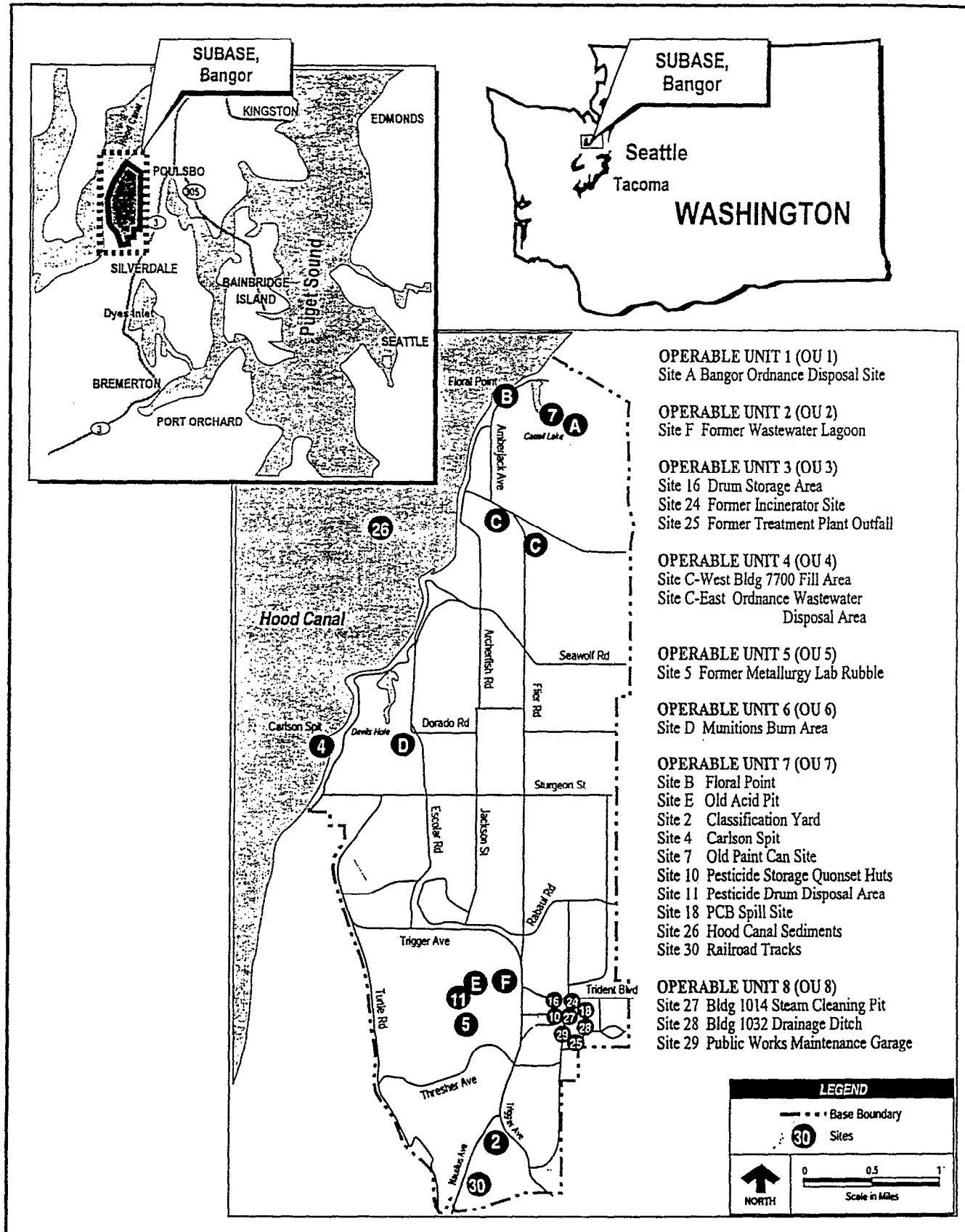

Figure 1-1. SUBASE Bangor General Location Map.
SUBASE Bangor OU 8.

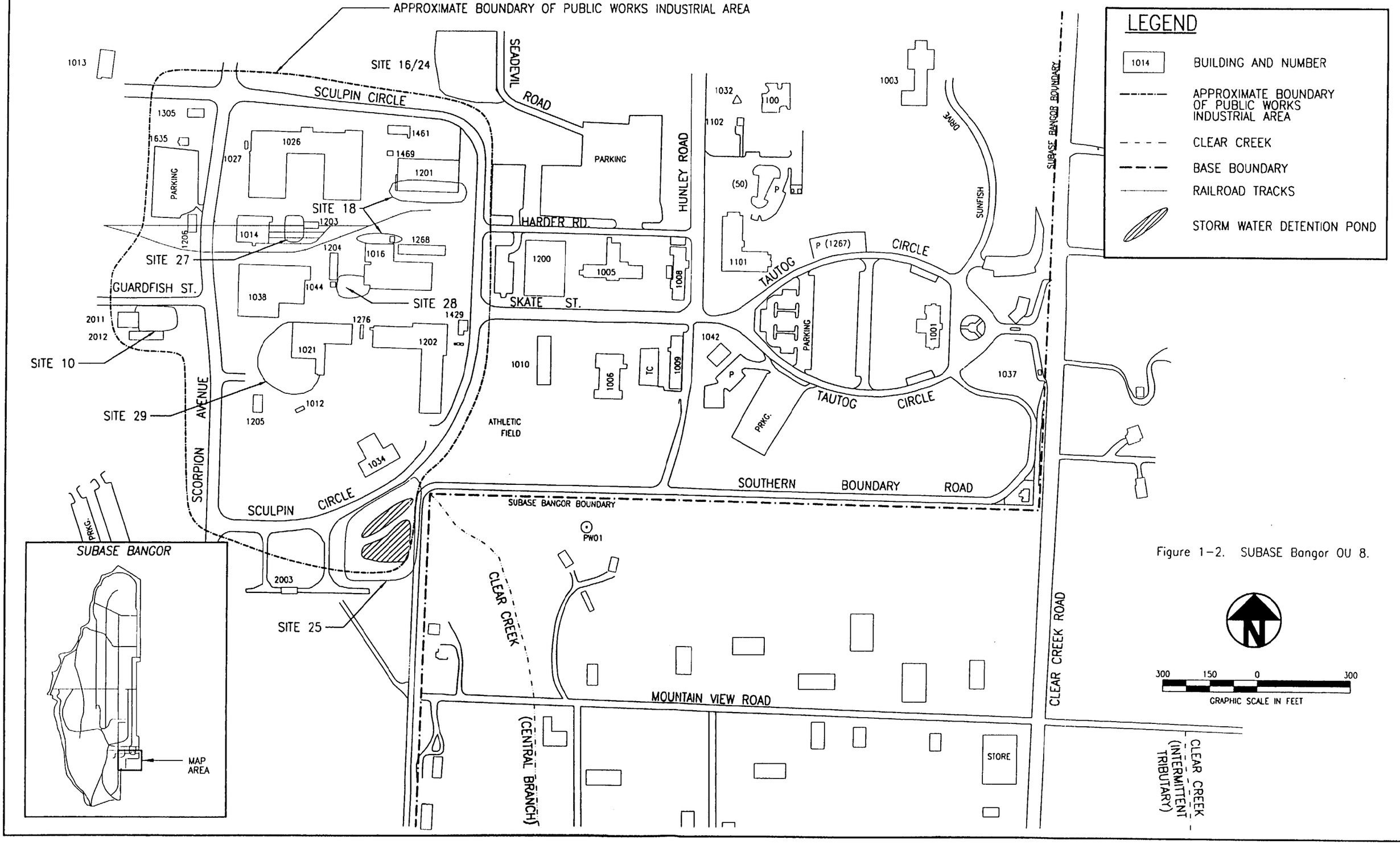

Figure 1-2. SUBASE Bangor OU 8.

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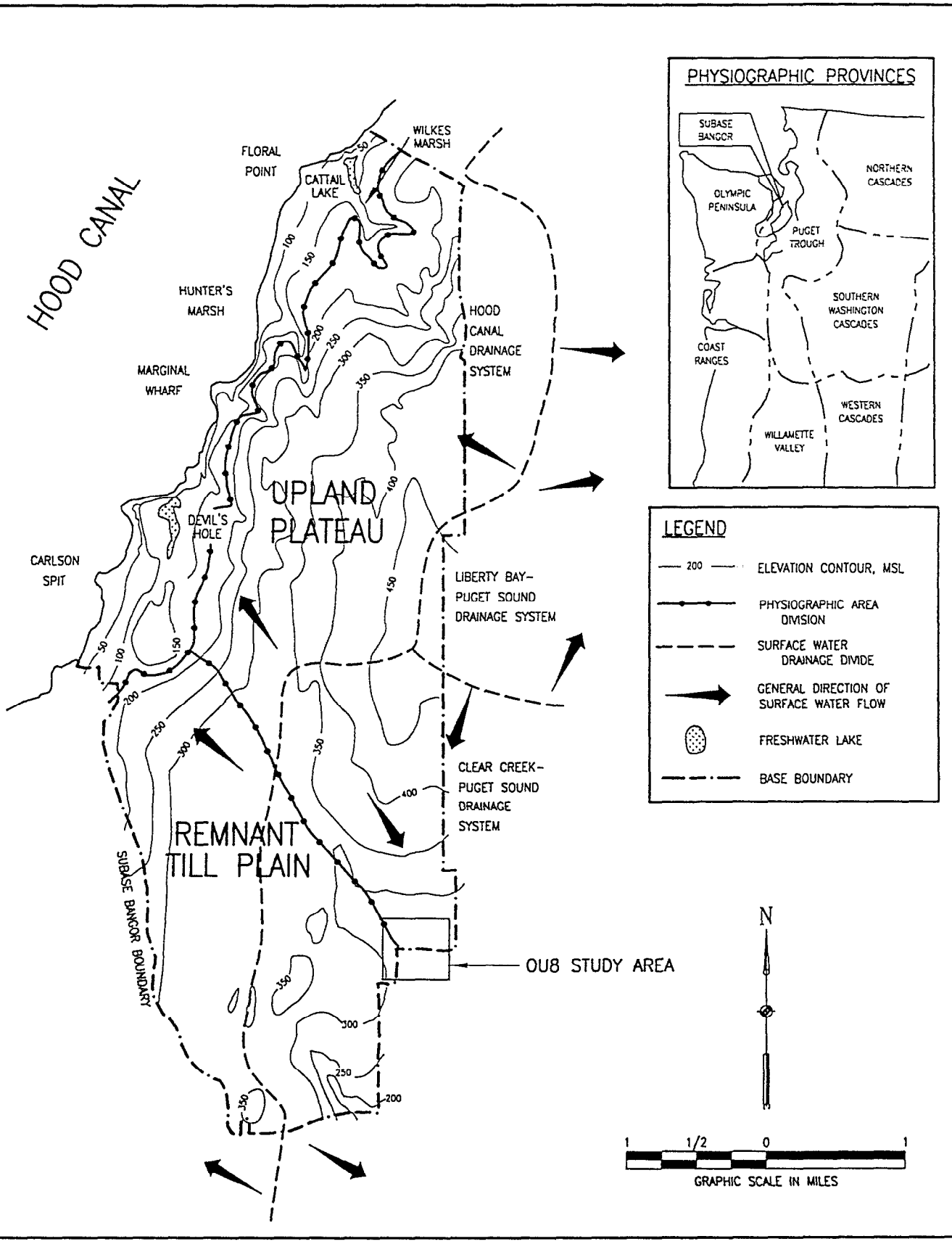

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Figure 5-1. SUBASE Bangor Physiography and Surface Water Hydrology.
SUBASE Bangor OU 8.

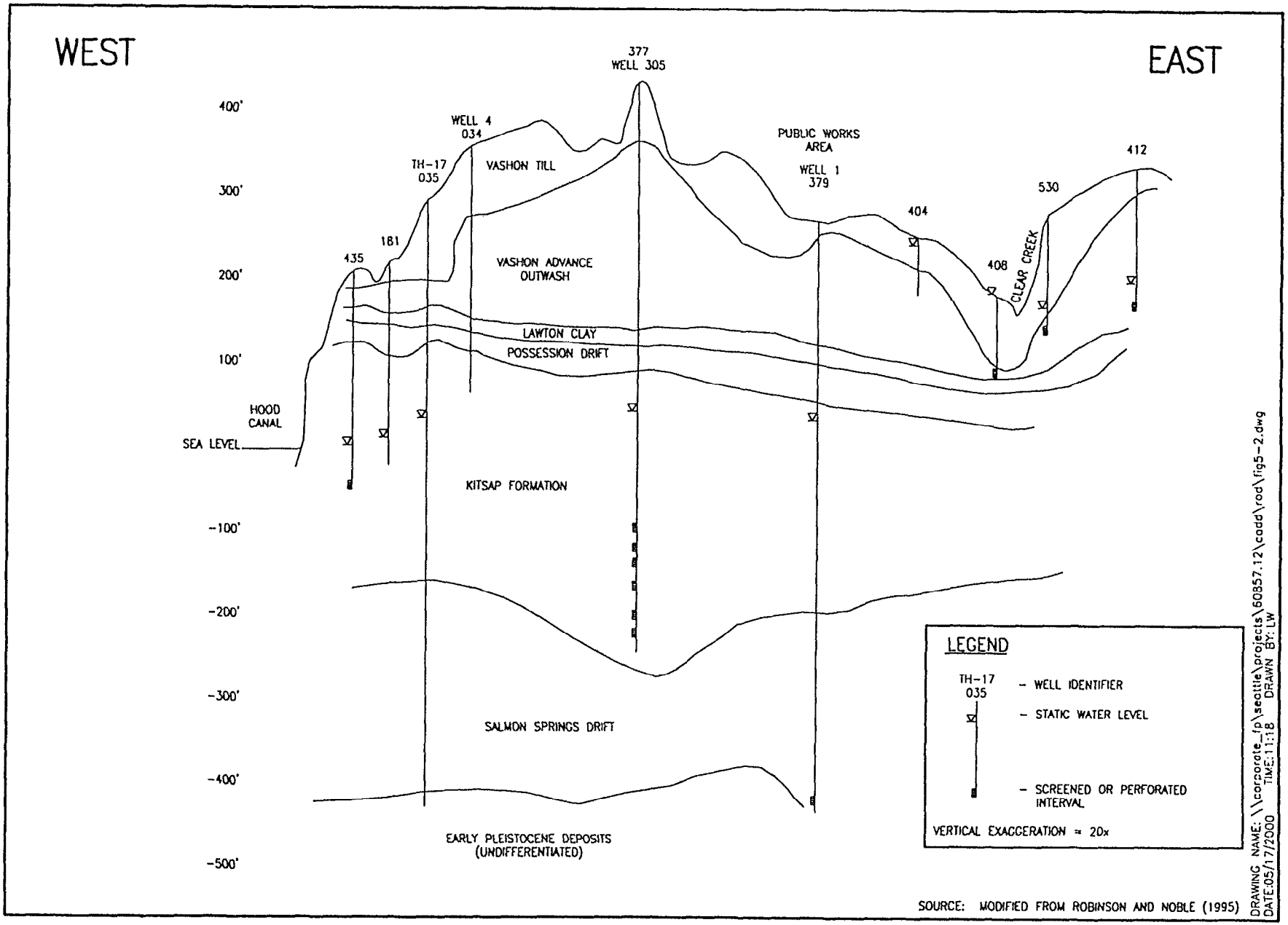

Figure 5-2. Generalized Geologic Cross-Section Through SUBASE Bangor.
SUBASE Bangor OU 8.

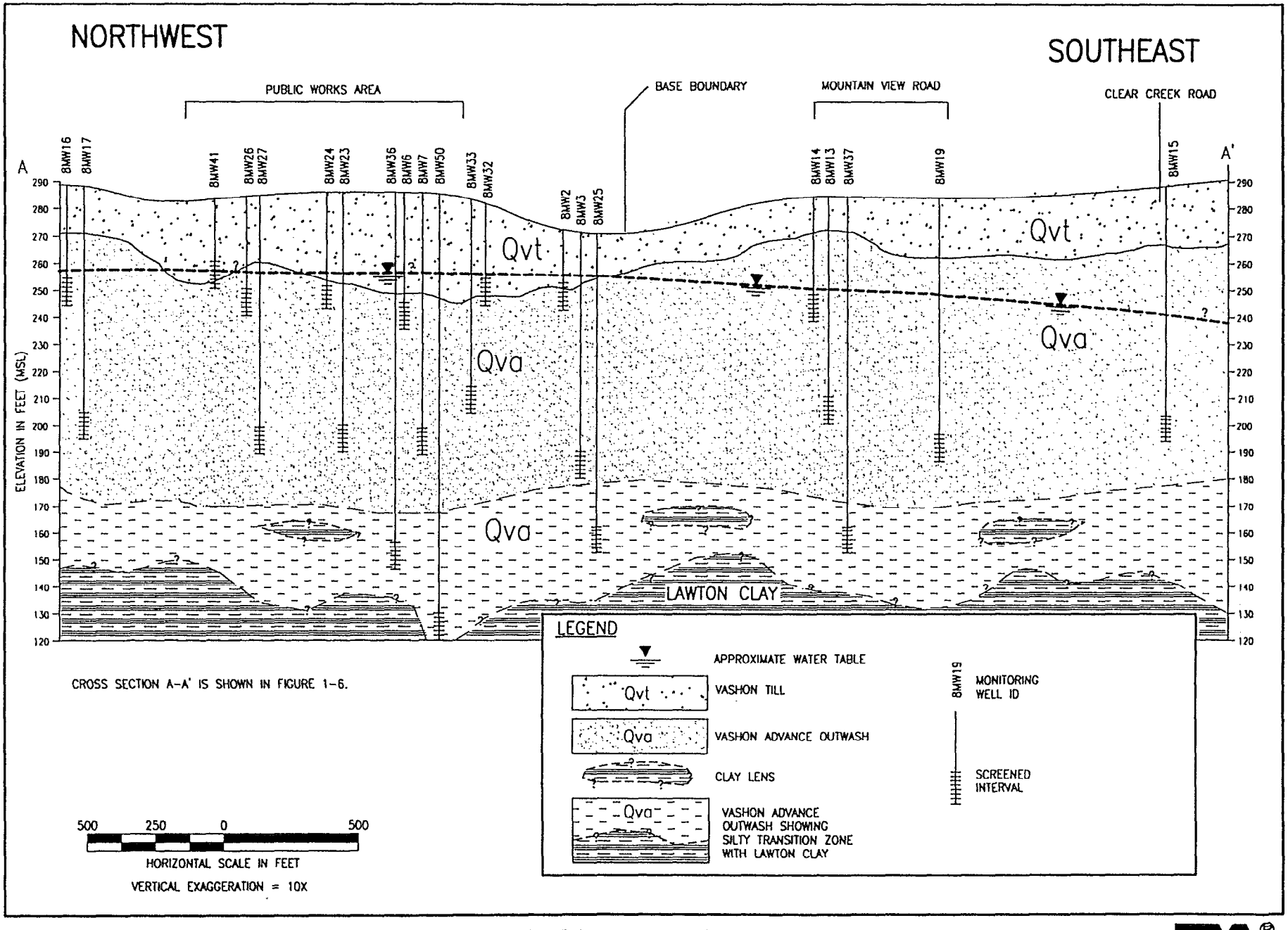

Figure 5-3. SUBASE Bangor OU 8 Geologic Cross-Section.

DRAWING NAME: \\corporate_fp\seattle\projects\60857.12\cadd\rod\fig5-3.dwg
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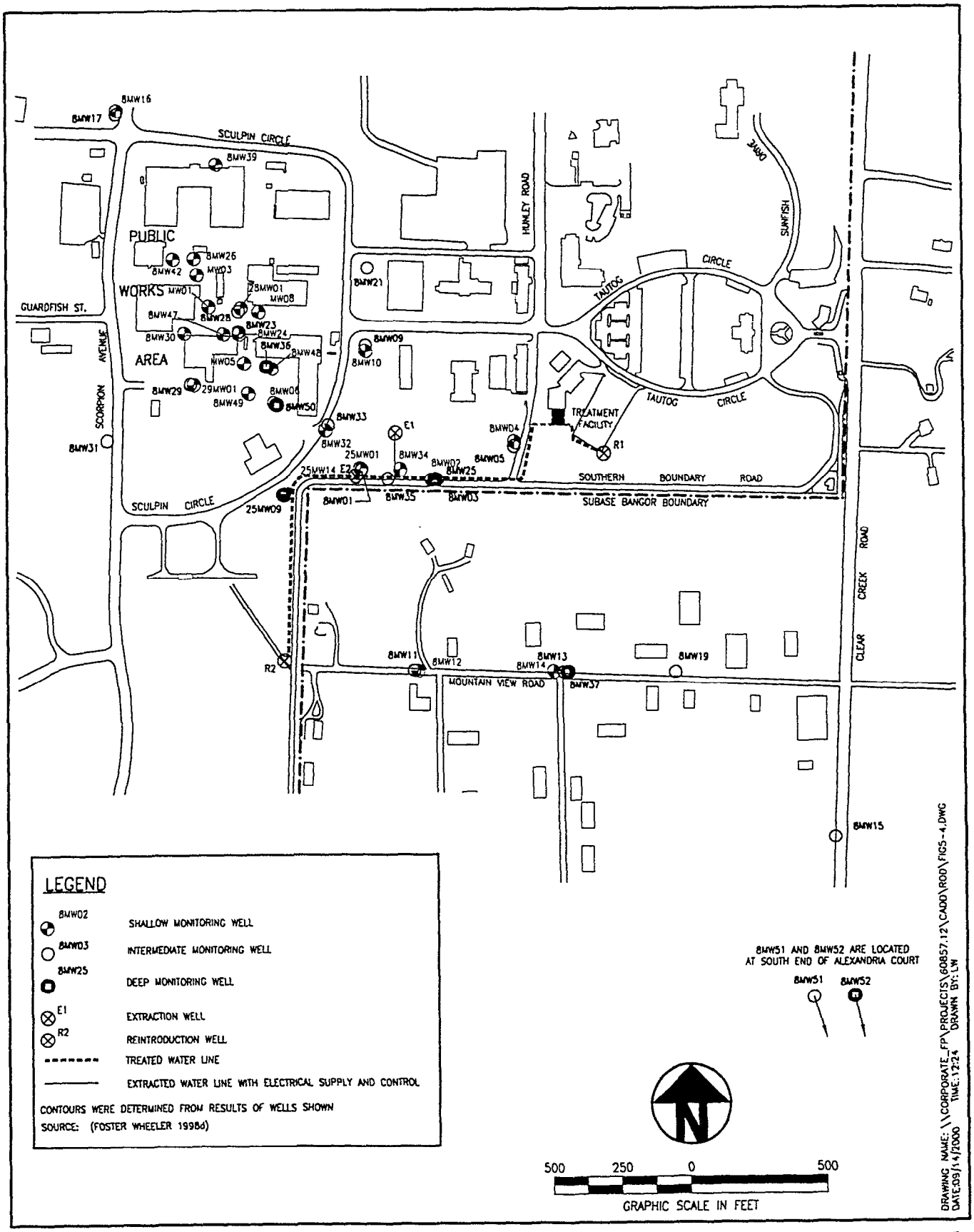
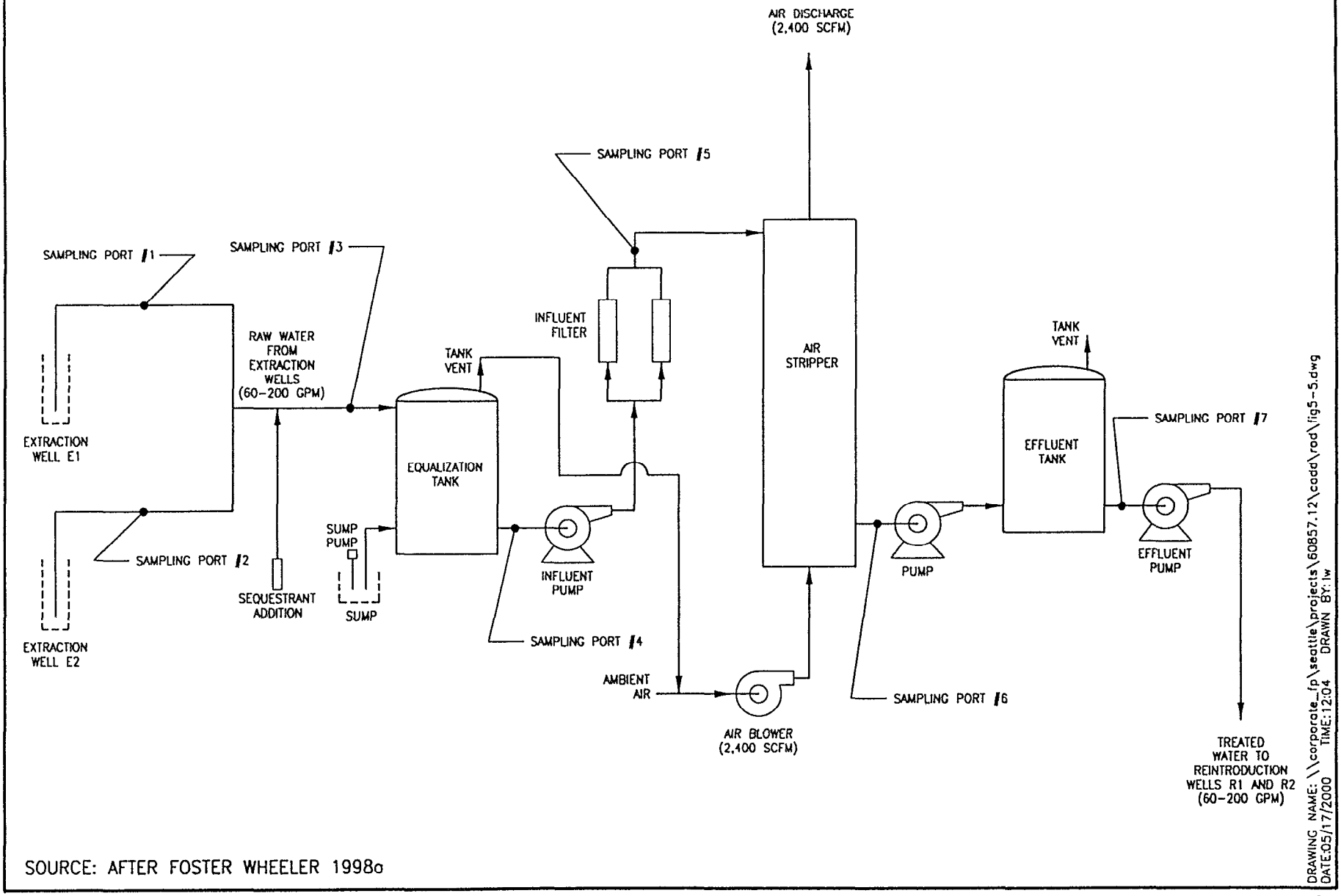


Figure 5-4. General Layout of the Inactive Pump-and-Treat (P&T) System. SUBASE Bangor OU8.



SOURCE: AFTER FOSTER WHEELER 1998a

Figure 5-5. Process Flow Diagram of the Existing Pump and Treat (P8-T) System.
SUBASE Bangor OU 8.

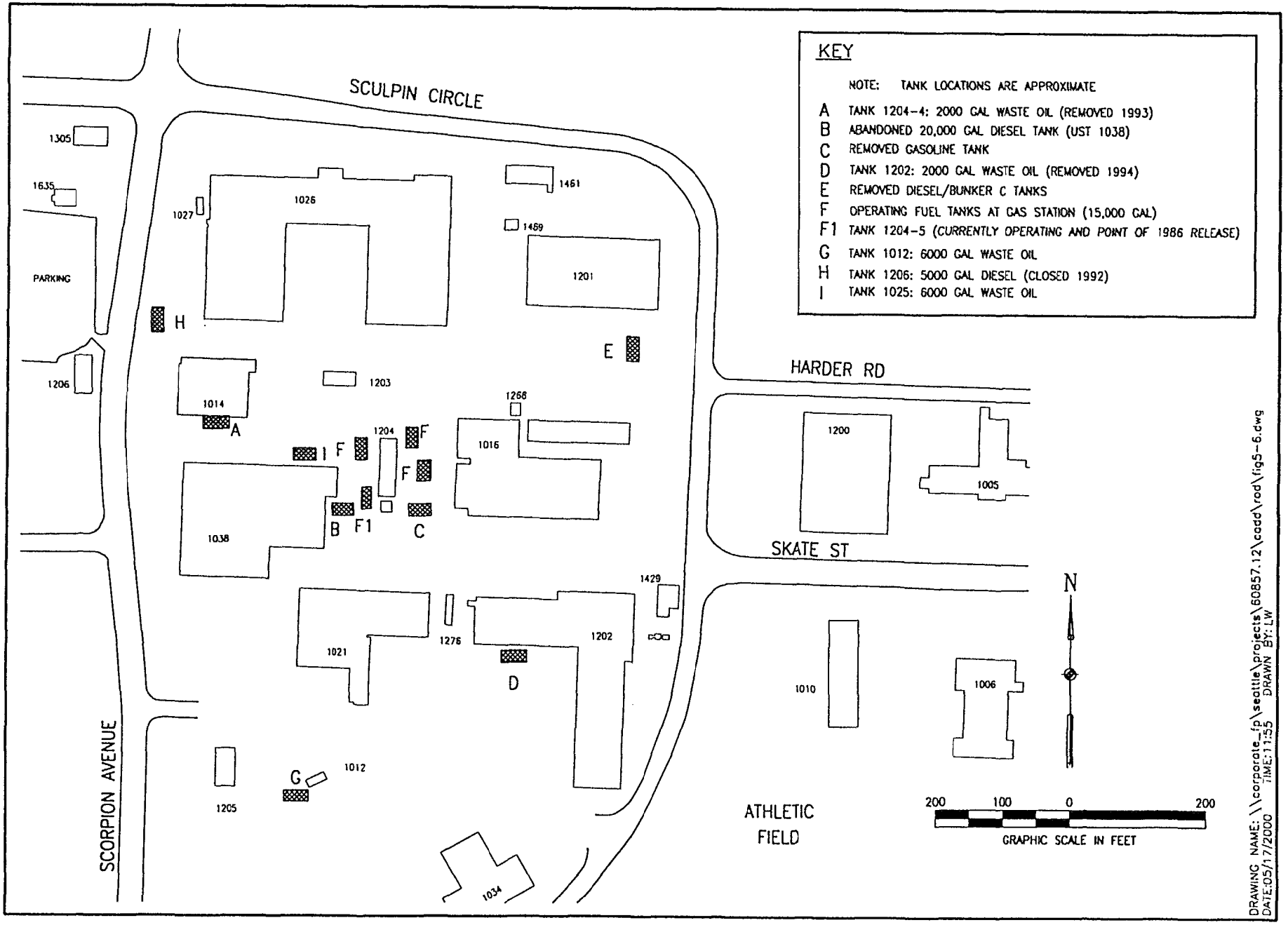
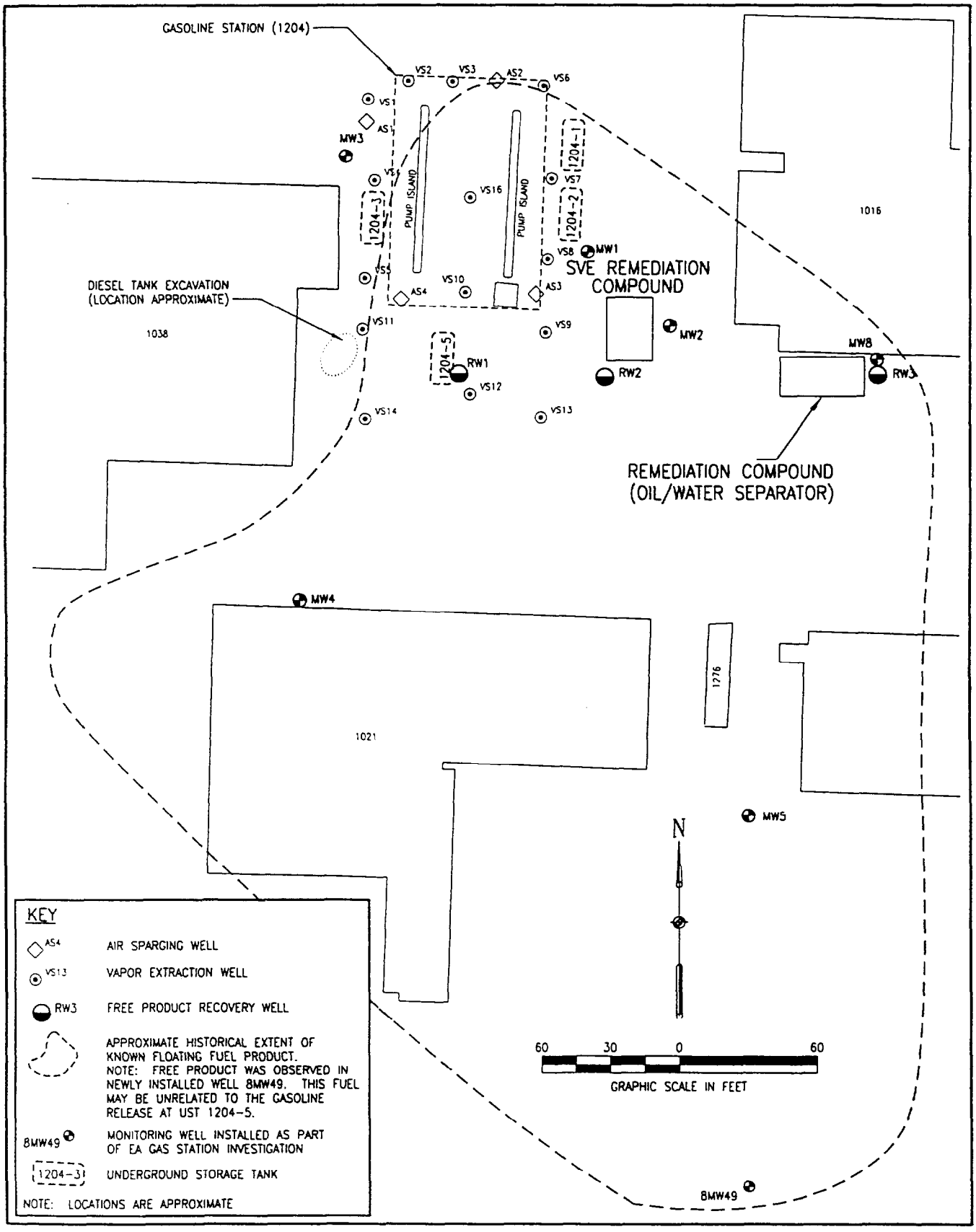


Figure 5-6. Abandoned and Existing Underground Storage Tanks in the PWIA.
SUBASE Bangor OU 8.



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DATE:09/14/2000 TIME:11:21 DRAWN BY: lw

Figure 5-7. Approximate Location of the Inactive Free Product Recovery (FPR) and Soil Vapor Extraction (SVE) Systems.
SUBASE Bangor OU 8.

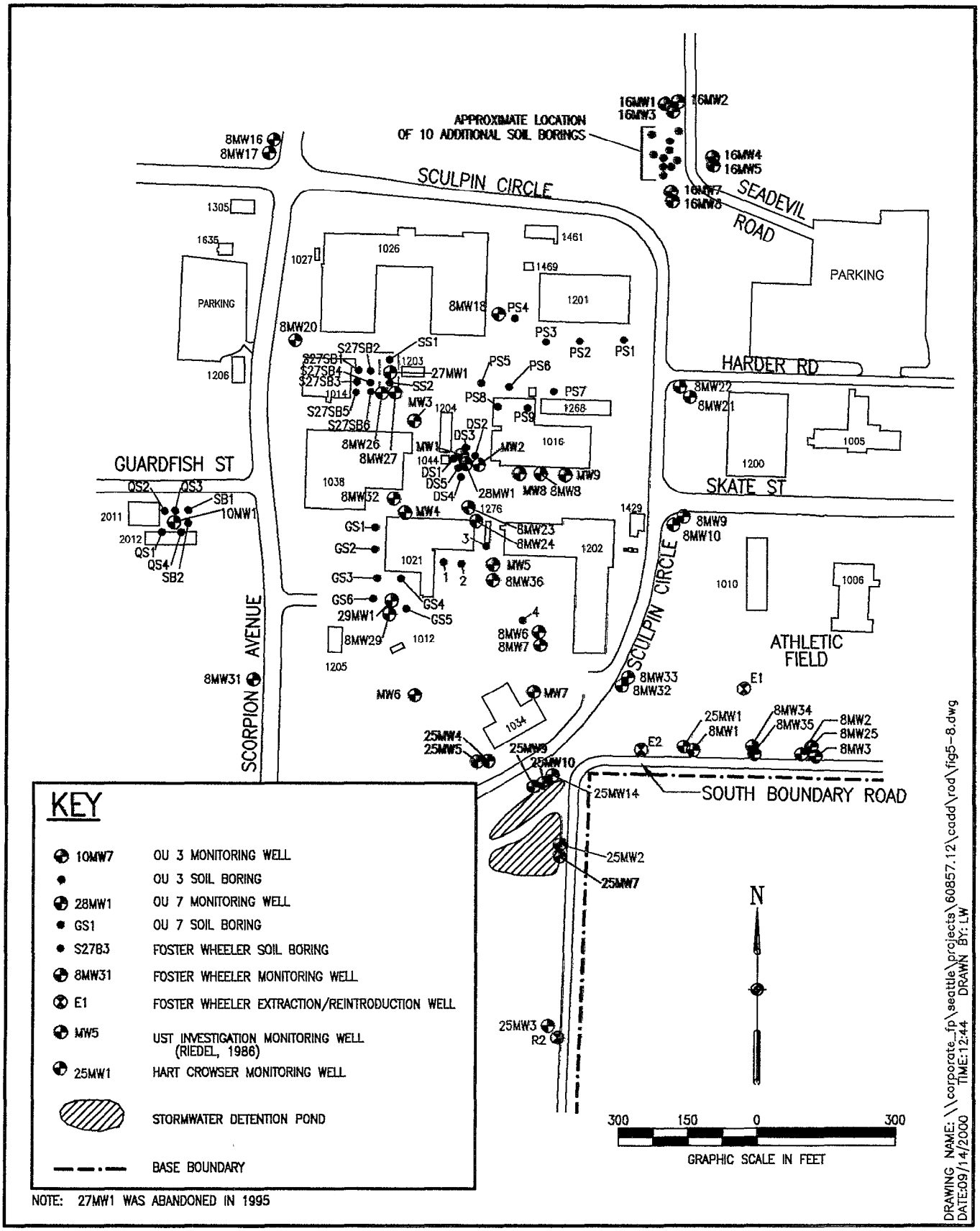


Figure 5-8. Previous Subsurface Soil Sampling Locations in the PWIA.
SUBASE Bangor OU 8.

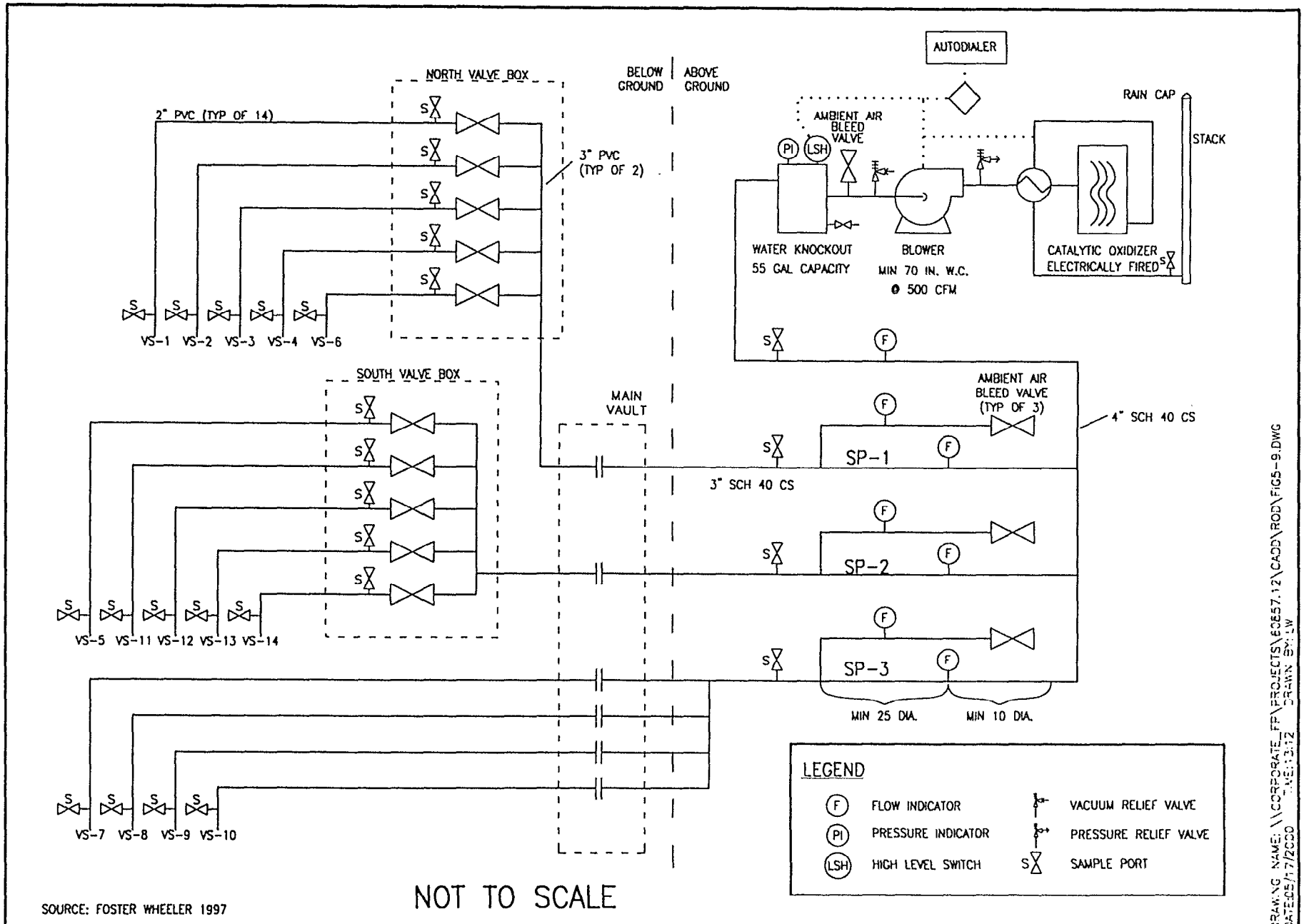


Figure 5-9. Process and Instrumentation Diagram of the Extisting Soil Vapor Extraction (SVE) System. SUBASE Bangor OU8.

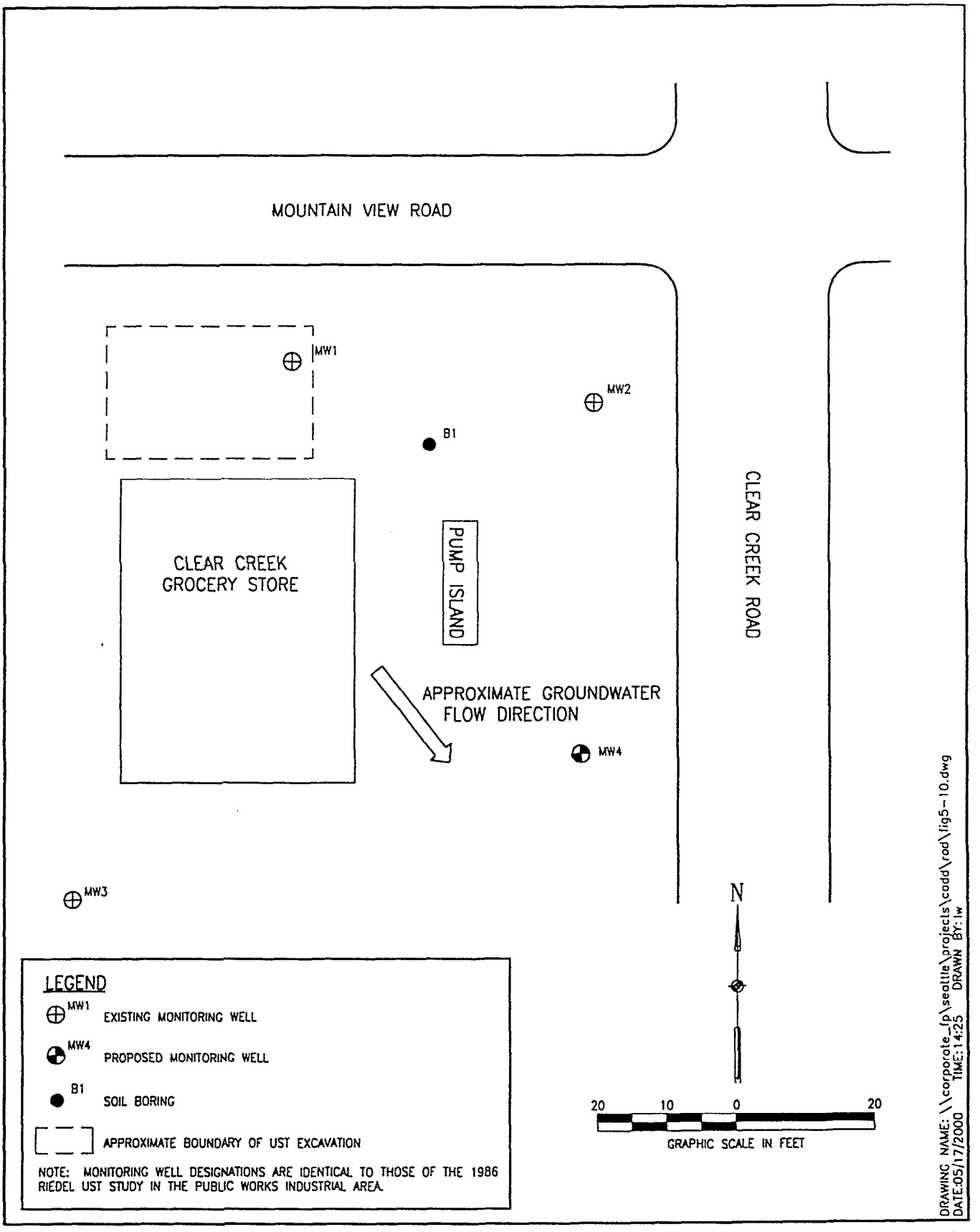


Figure 5-10. Clear Creek Grocery Underground Storage Tank Investigation. SUBASE Bangor OU 8.

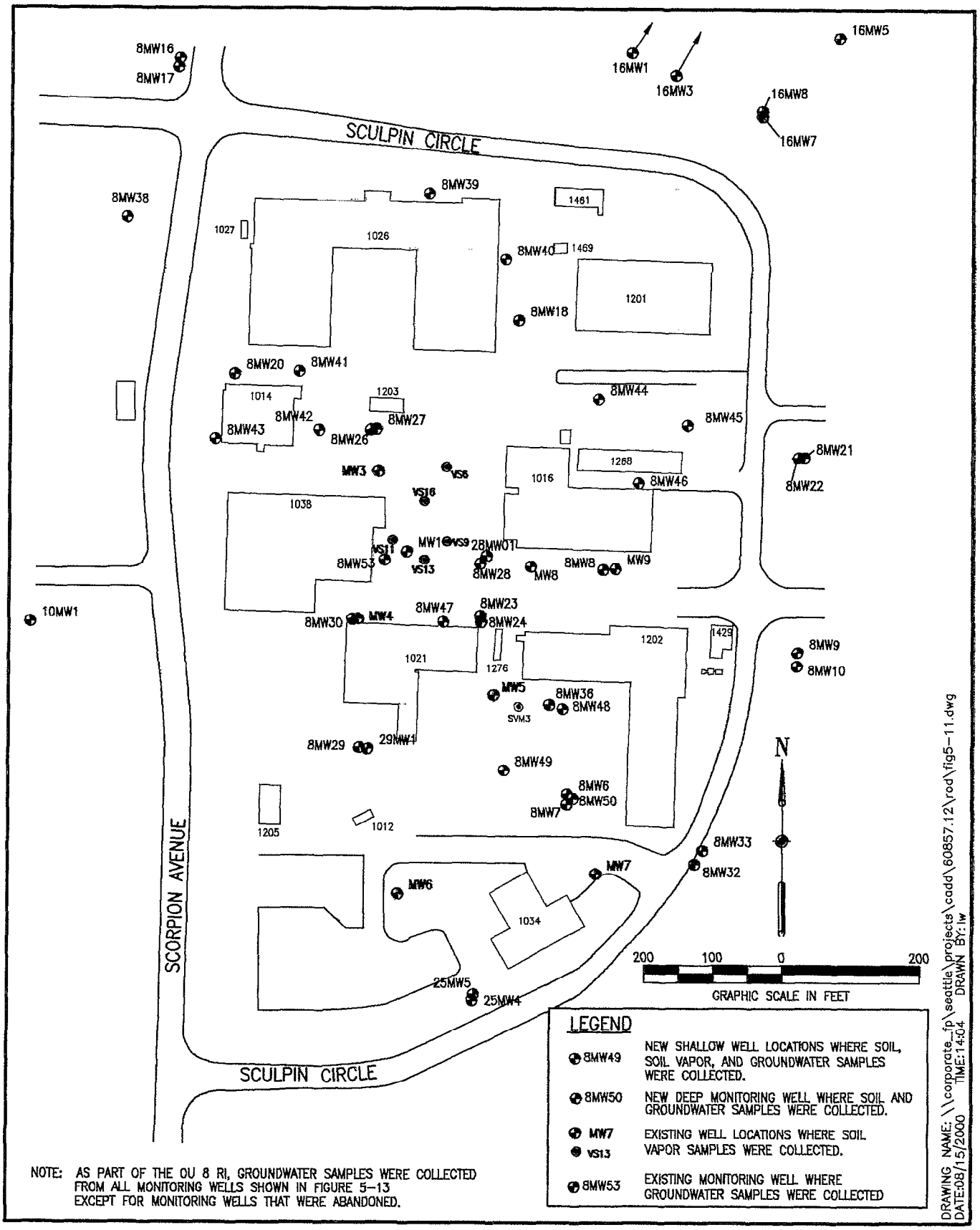


Figure 5-11. Sampling Locations in the PWIA.
SUBASE Bangor OU 8.

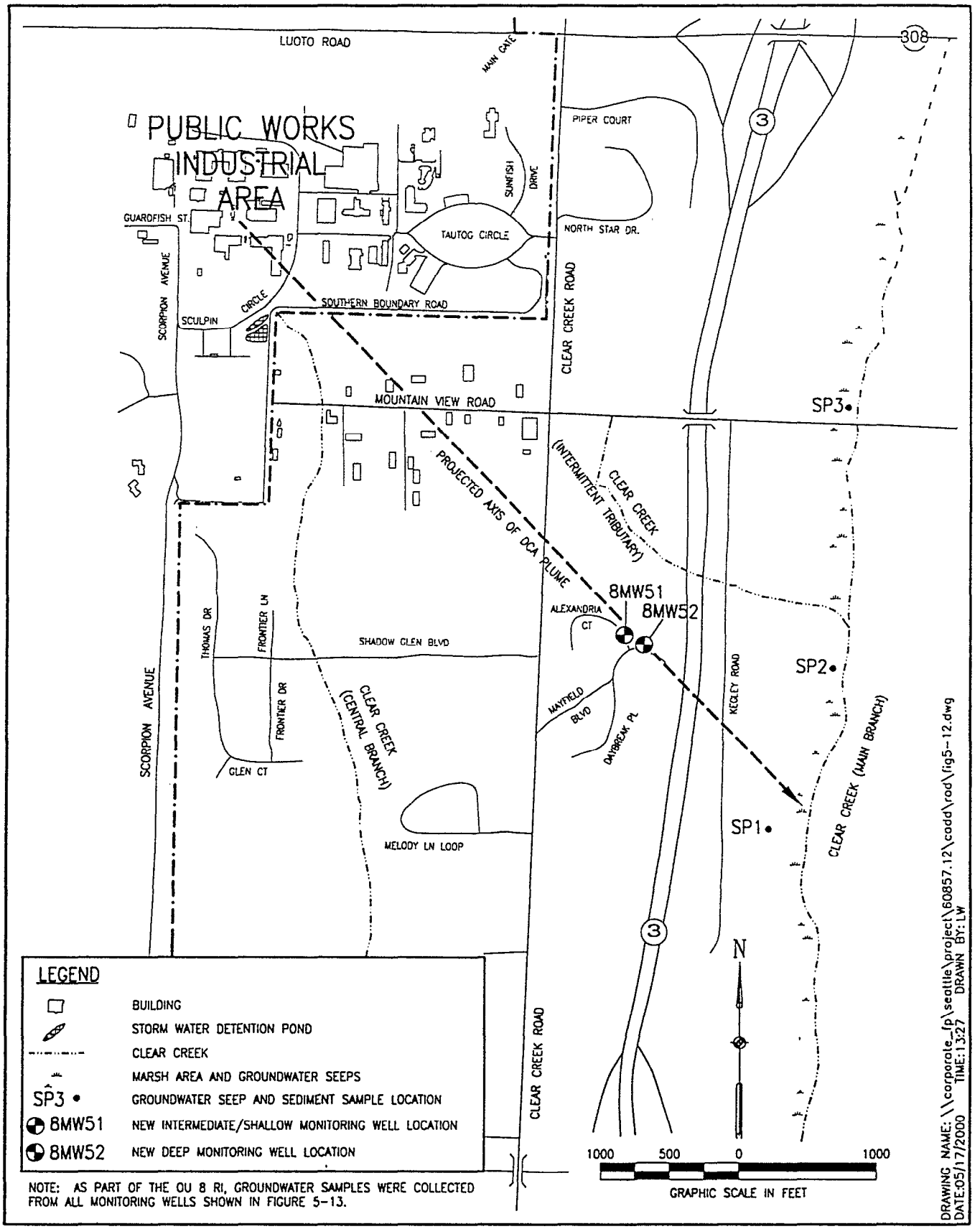
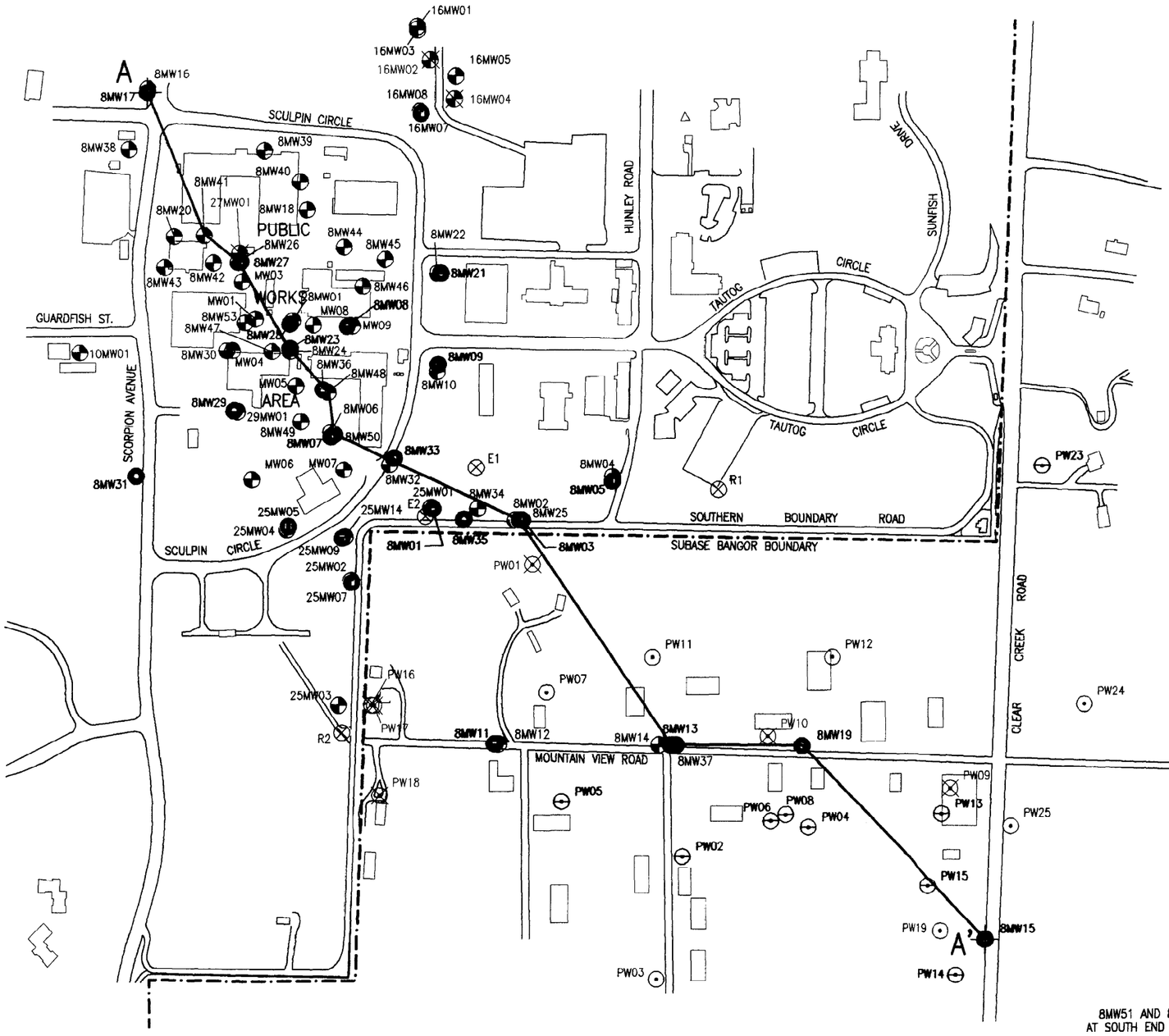


Figure 5-12. Sampling Locations East of Clear Creek Road.
SUBASE Bangor OU 8.



LEGEND

SHALLOW WELLS (COMPLETED WITHIN 30 FEET OF WATER TABLE):

- 8MW02 — MONITORING WELL
- PW10 — SUPPLY WELL

INTERMEDIATE WELLS (APPROXIMATE COMPLETION DEPTH 220–180' MSL):

- 8MW03 — MONITORING WELL
- PW15 — SUPPLY WELL

DEEP WELLS (COMPLETED WITHIN APPROXIMATELY 30' OF LAWTON CLAY):

- 8MW25 — MONITORING WELL

OTHER WELLS:

- E1 — EXTRACTION WELL
- R2 — REINTRODUCTION WELL

ABANDONED WELLS:

- 27MW01 — ABANDONED MONITORING WELL
- PW18 — ABANDONED SUPPLY WELL

NOT ALL ABANDONED WELLS ARE SHOWN.

CROSS SECTION A–A' IS DEPICTED IN FIGURE 5–3.

8MW51 AND 8MW52 ARE LOCATED AT SOUTH END OF ALEXANDRIA COURT

8MW51 8MW52

Figure 5–13. Well Locations in OU 8.

SUBASE Bangor OU 8.

N

400 200 0 400

GRAPHIC SCALE IN FEET

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DATE:05/17/2000 TIME:13:45 DRAWN BY: lw

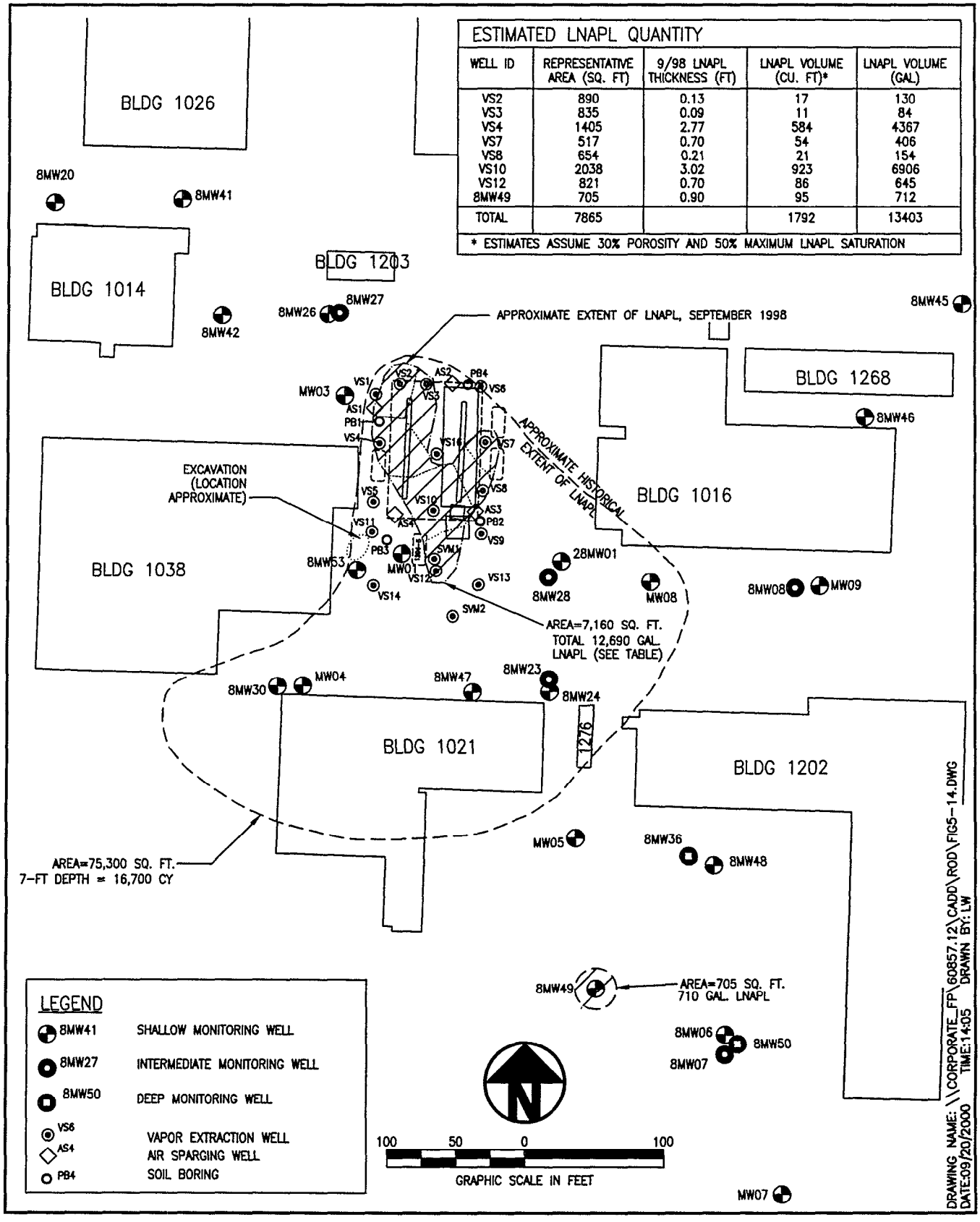


Figure 5-14. Extent and Estimated Quantity of LNAPL Beneath the PWIA. SUBASE Bangor OU8.

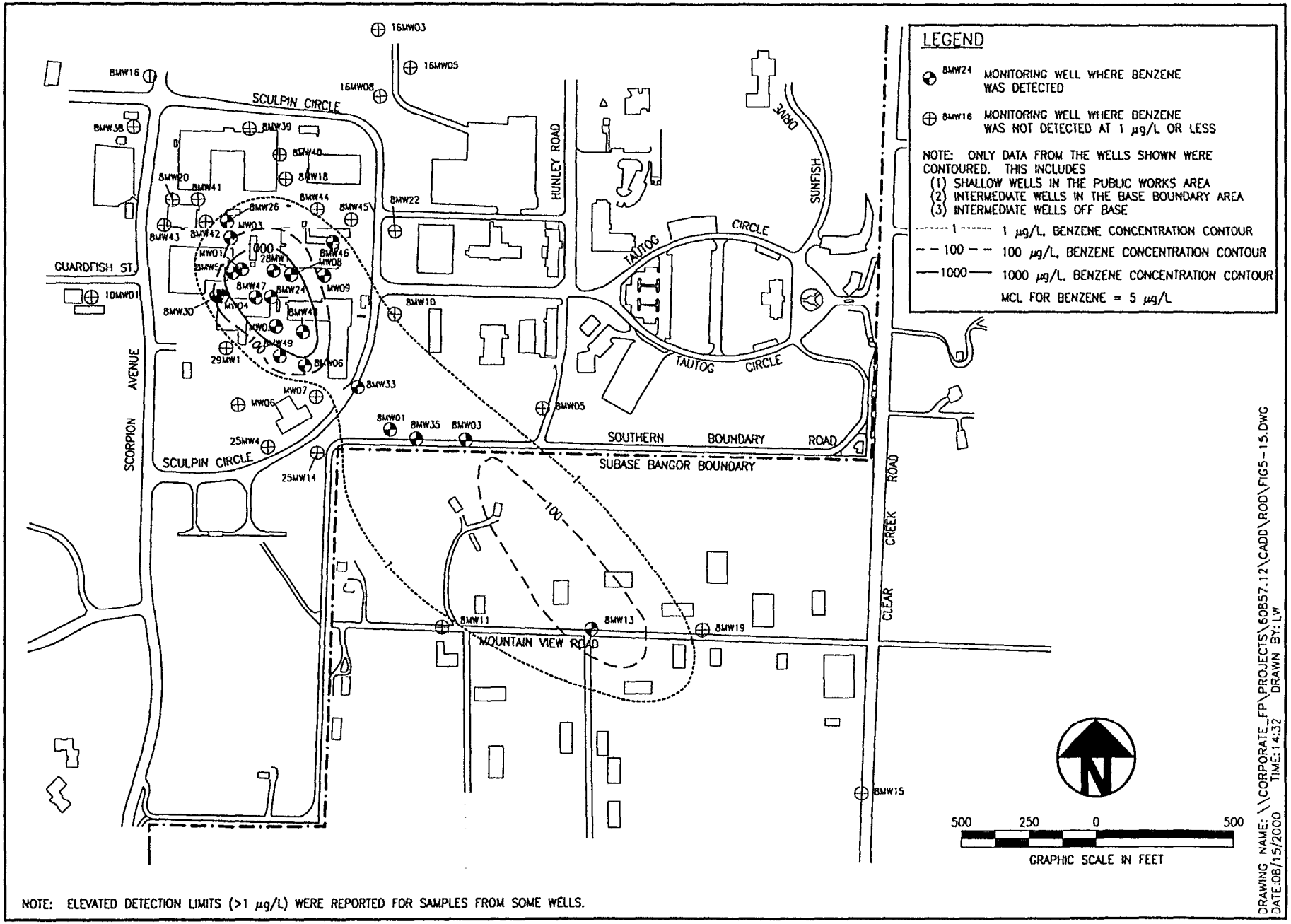
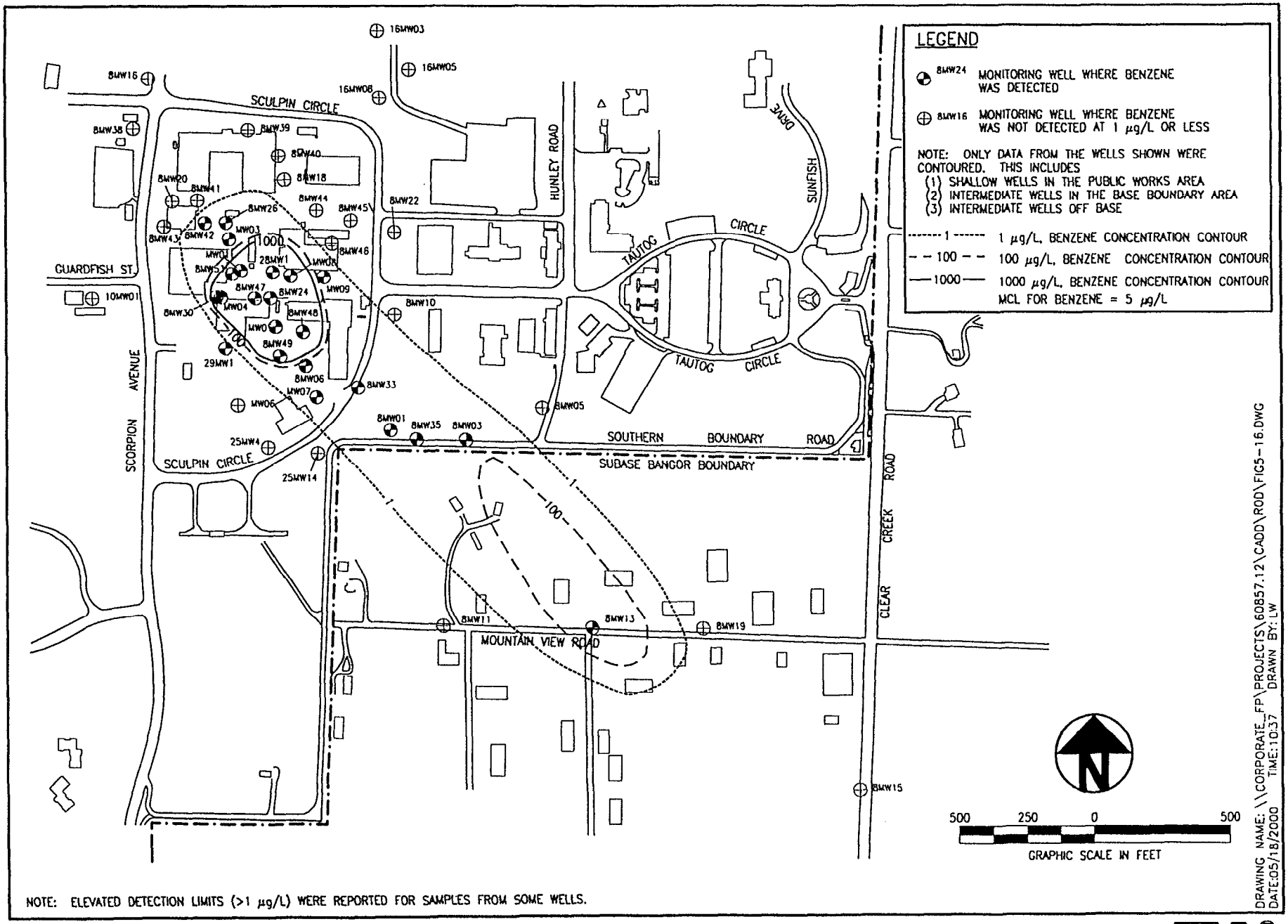


Figure 5-15. Concentration Contours for Benzene in Groundwater, in 1995.
SUBASE Bangor OU8.



NOTE: ELEVATED DETECTION LIMITS (>1 µg/L) WERE REPORTED FOR SAMPLES FROM SOME WELLS.

Figure 5-16. Concentration Contours for Benzene in Groundwater, in 1996.
SUBASE Bangor OU8.

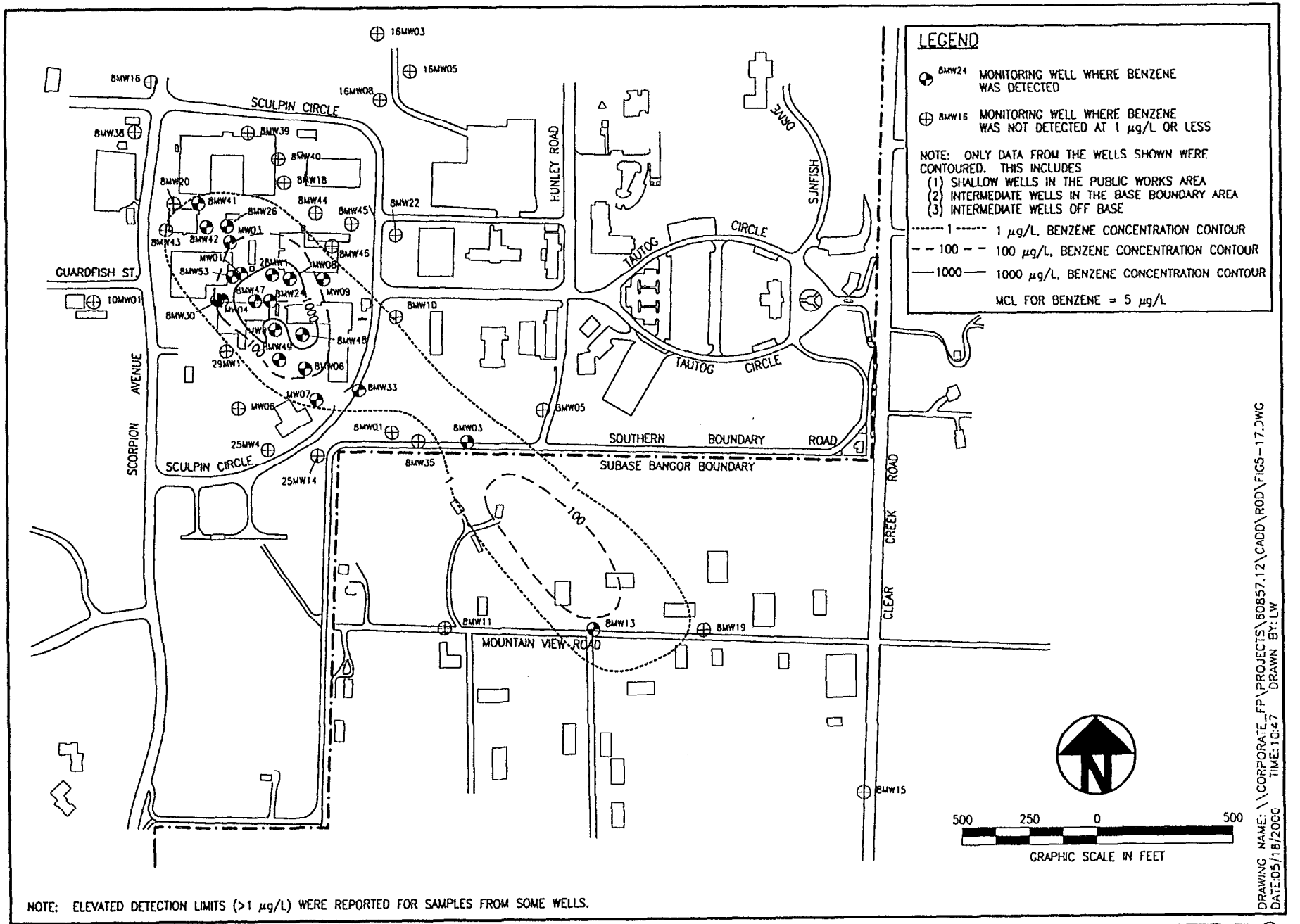


Figure 5-17. Concentration Contours for Benzene in Groundwater, in 1997.
SUBASE Bangor OU8.

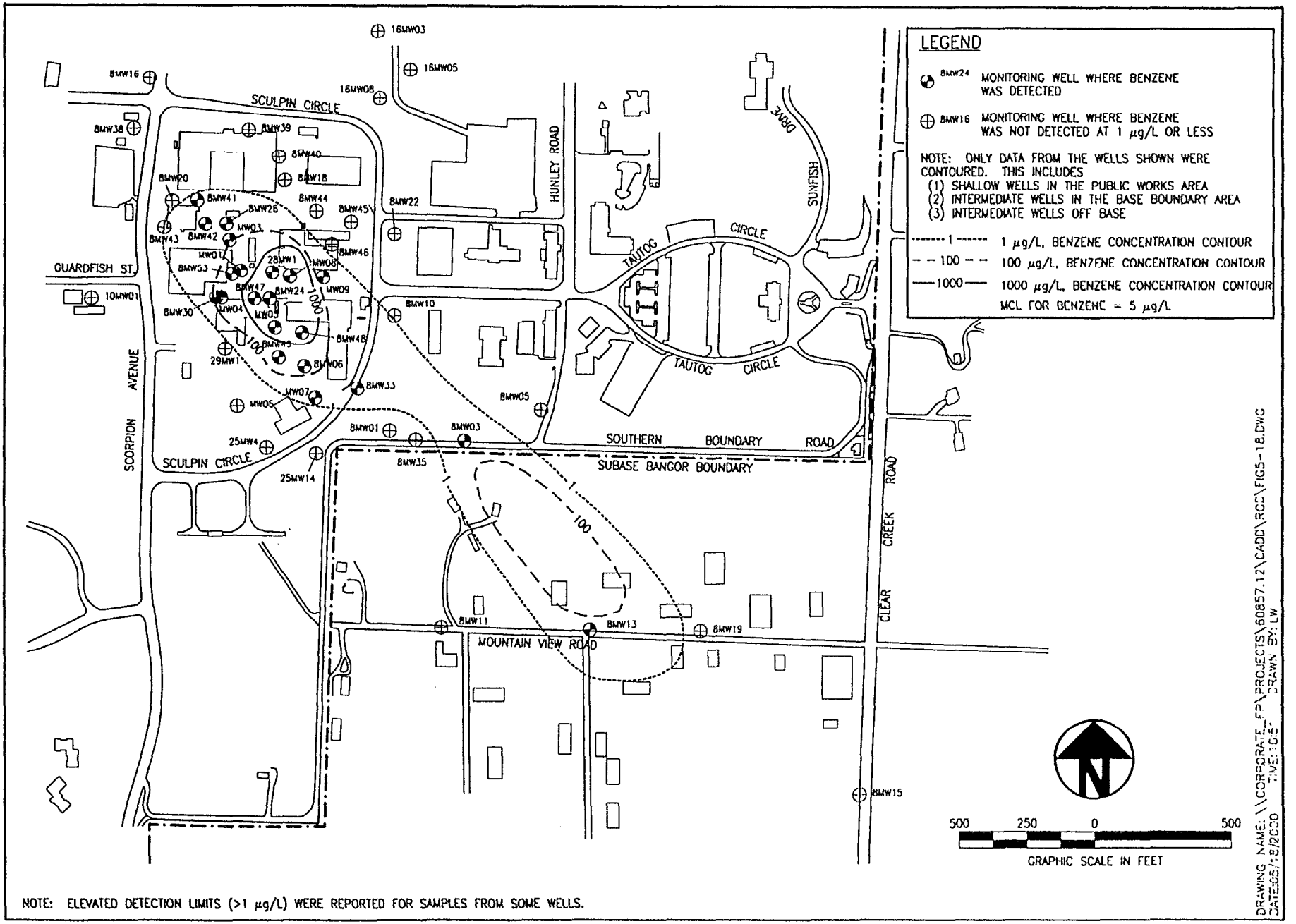


Figure 5-18. Concentration Contours for Benzene in Groundwater, in 1998.
SUBASE Bangor OU8.

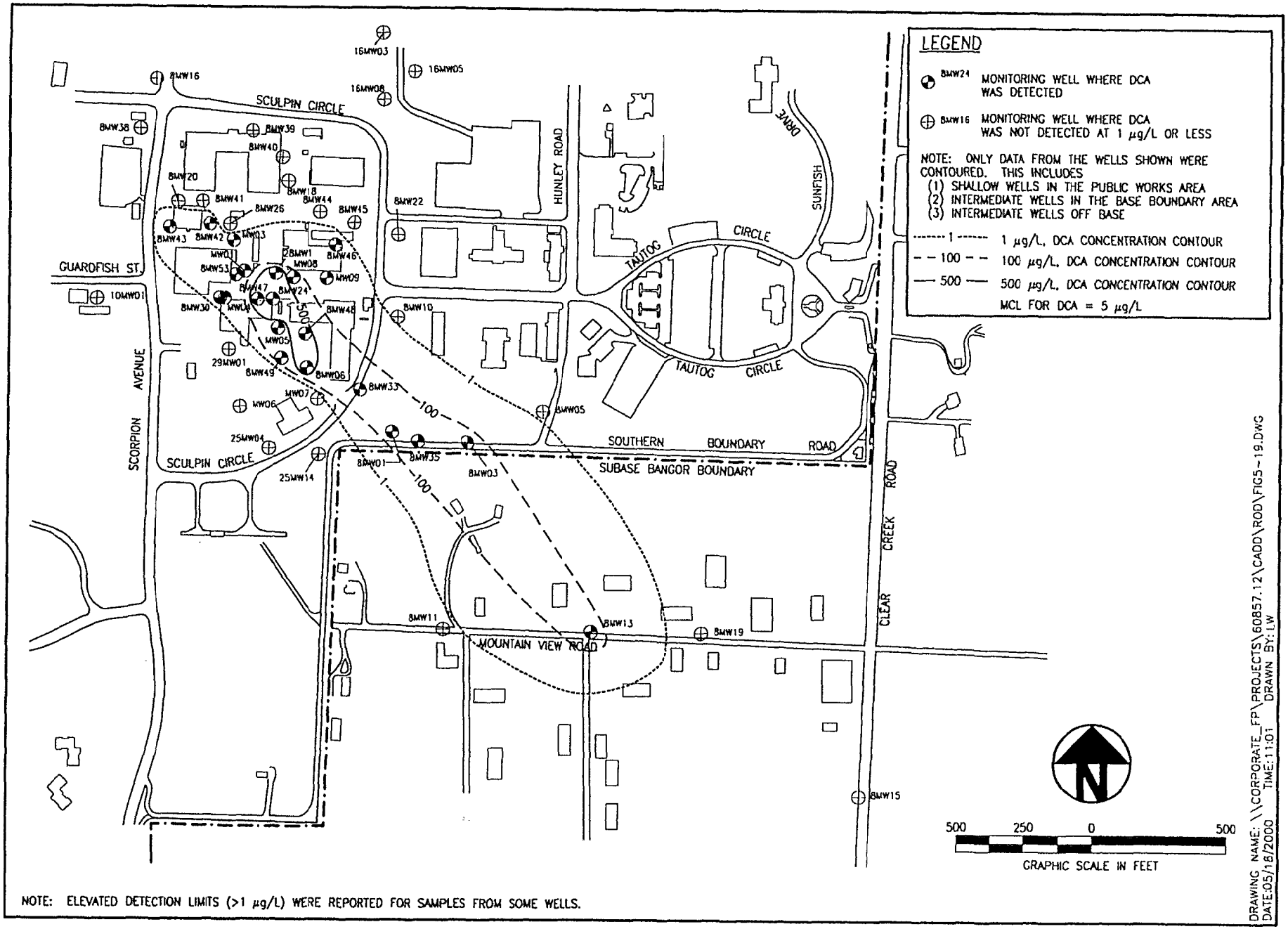


Figure 5-19. Concentration Contours for DCA in Groundwater, in 1995.
SUBASE Bangor OUB.

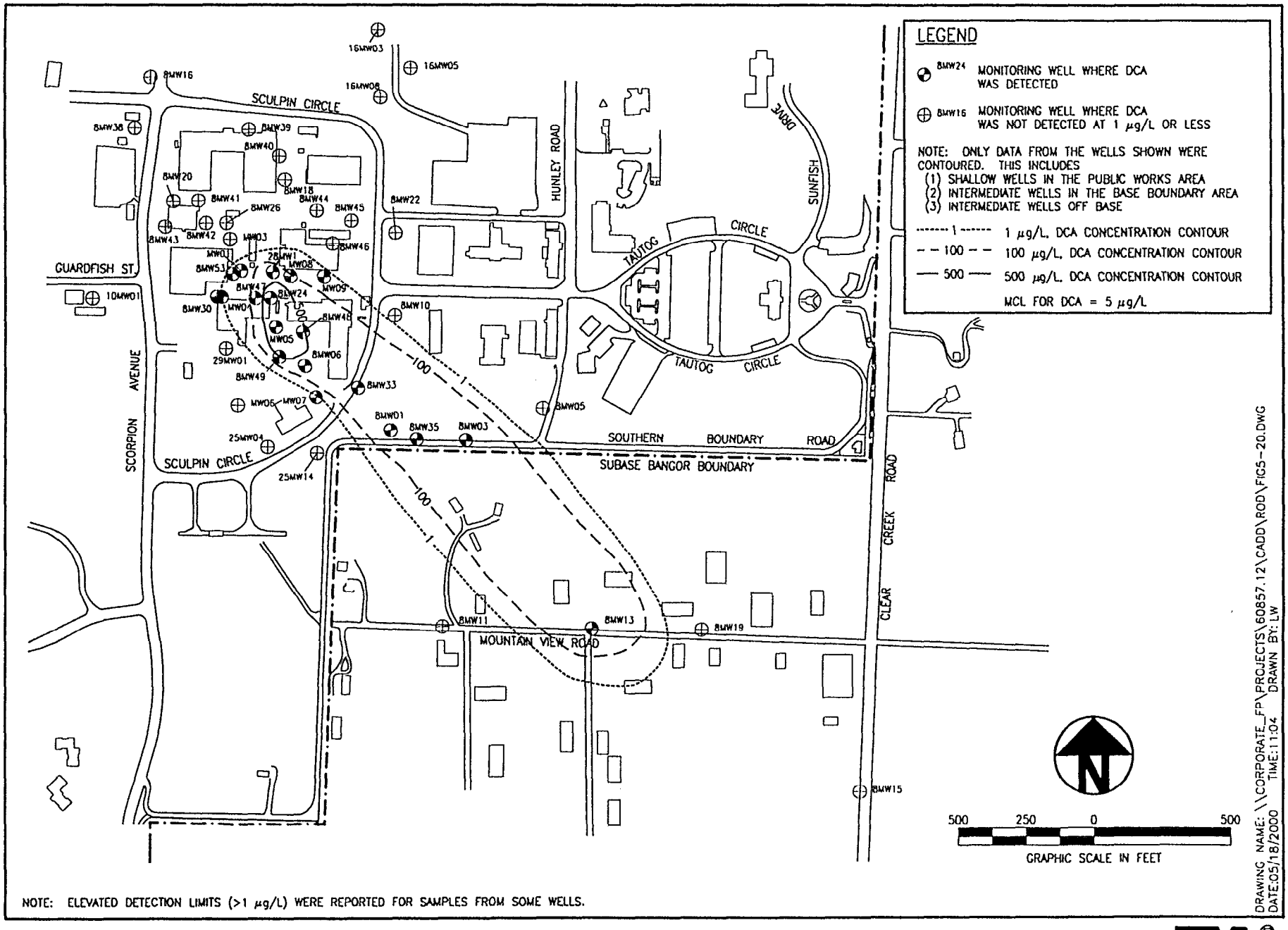
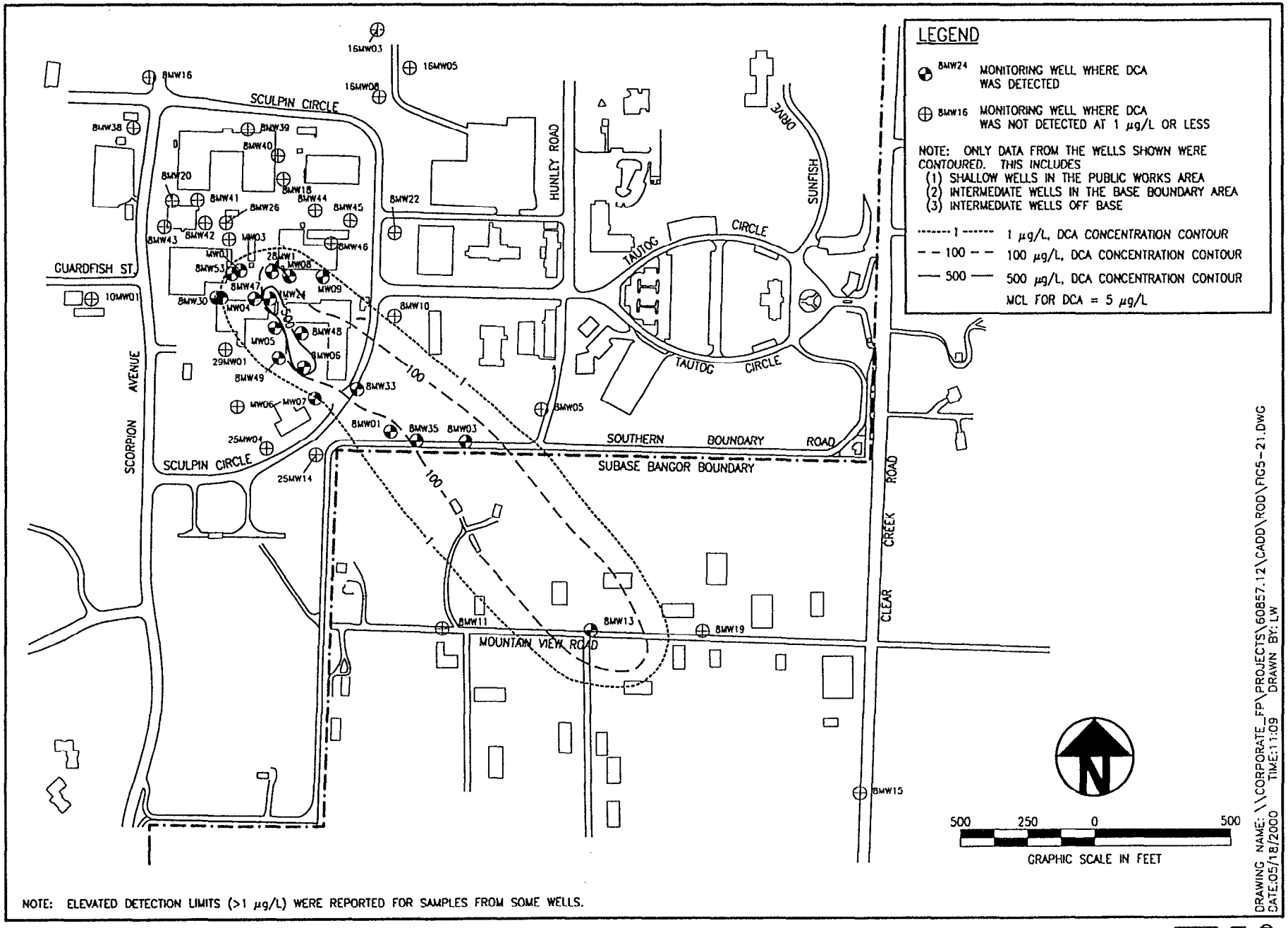


Figure 5-20. Concentration Contours for DCA in Groundwater, in 1996.
SUBASE Bangor OU8.



NOTE: ELEVATED DETECTION LIMITS (>1 µg/L) WERE REPORTED FOR SAMPLES FROM SOME WELLS.

Figure 5-21. Concentration Contours for DCA in Groundwater, in 1997.
SUBASE Bangor OU8.

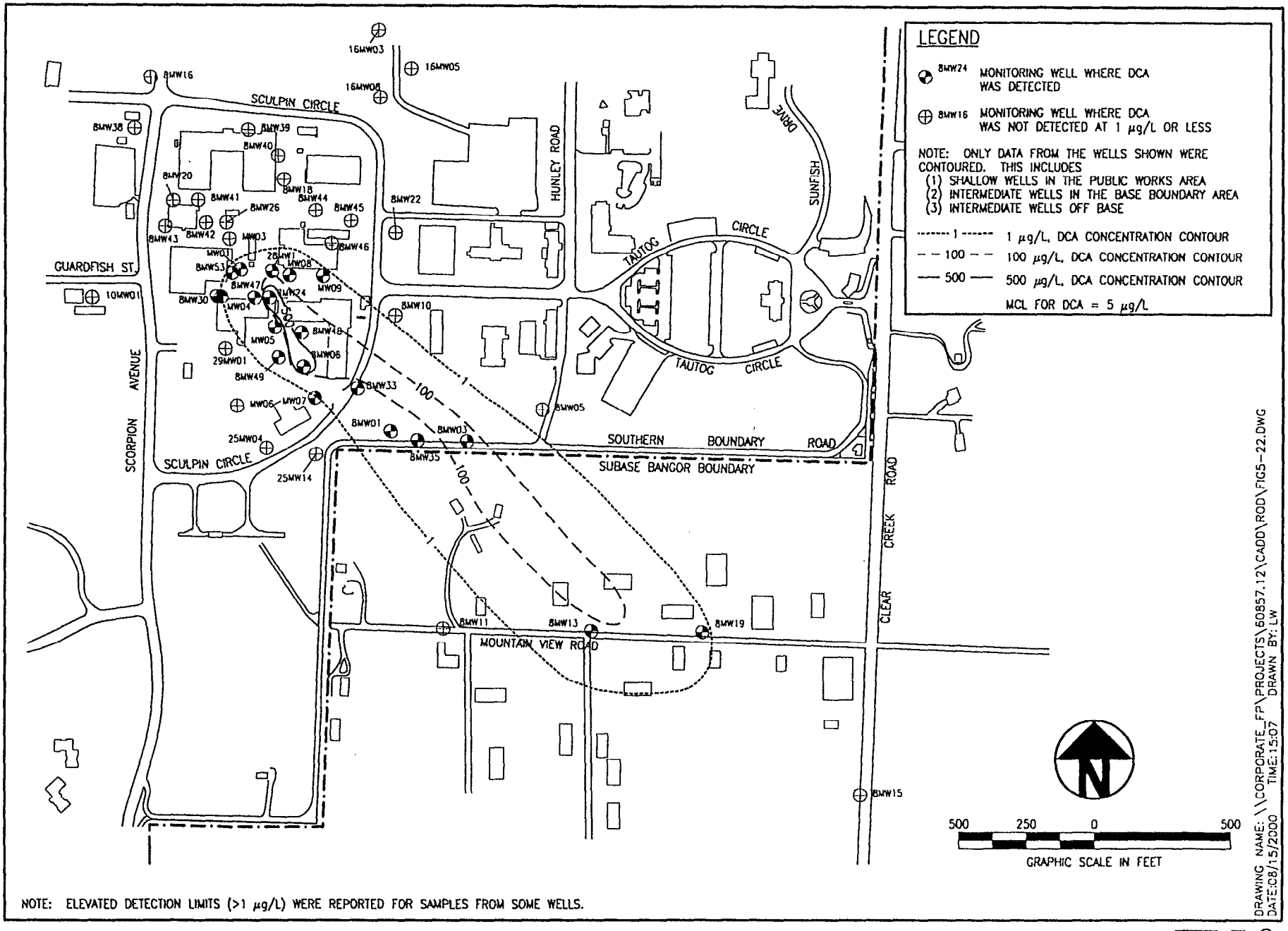


Figure 5-22. Concentration Contours for DCA in Groundwater, in 1998.
SUBASE Bangor OU8.

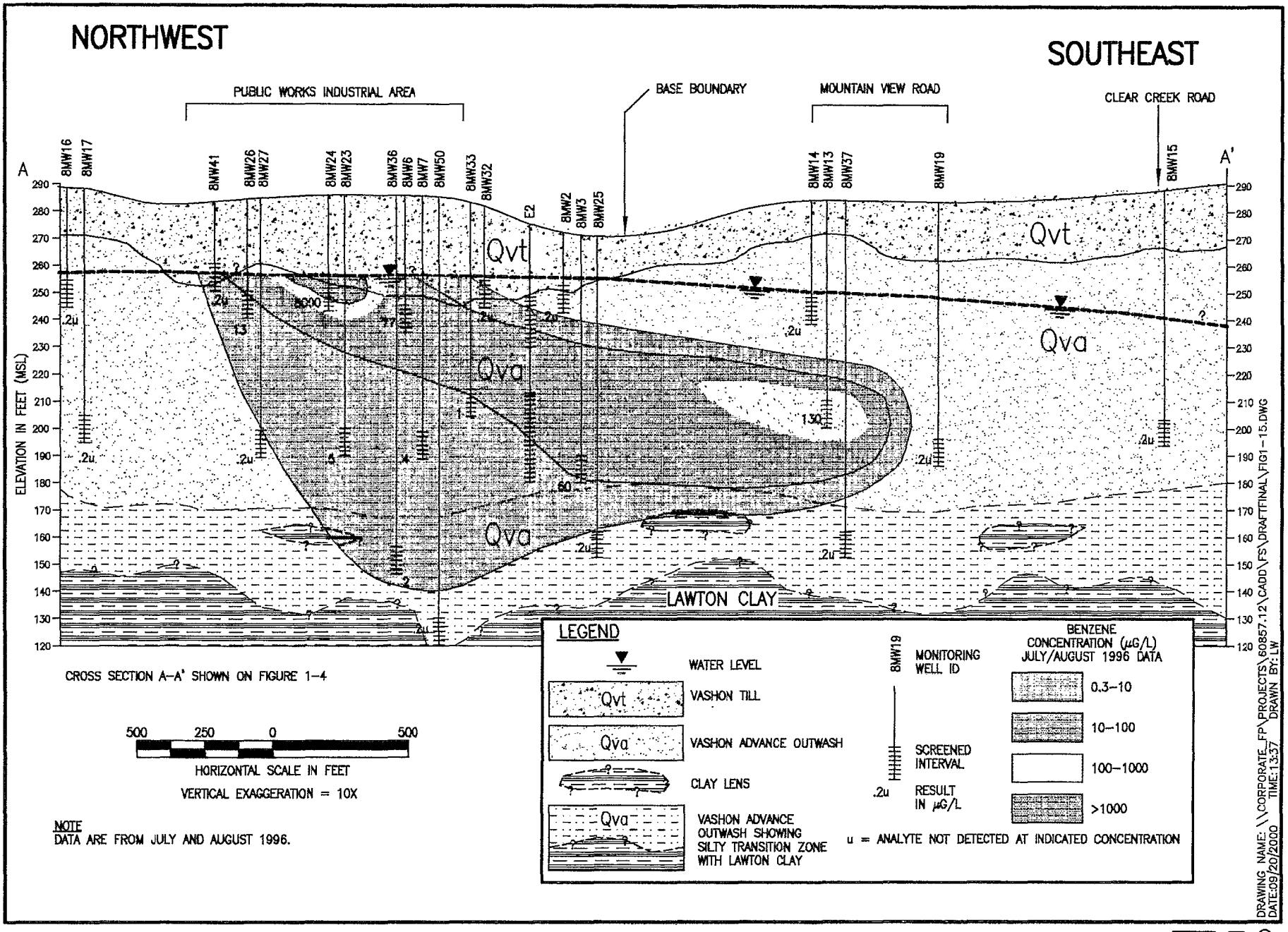


Figure 5–23. OU 8 Geologic Cross–Section Showing Benzene Concentrations, in 1996.
SUBASE Bangor OU8.

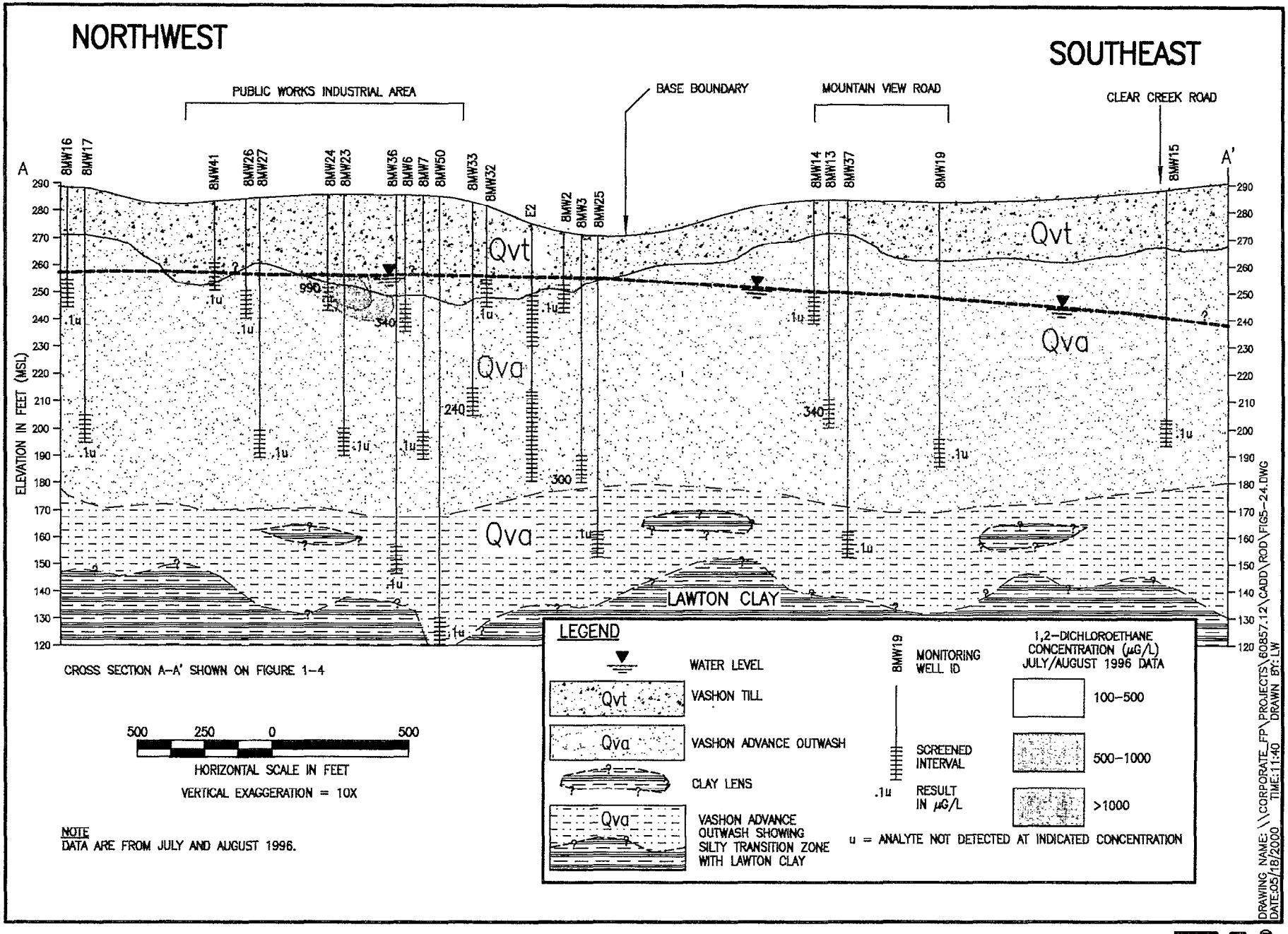


Figure 5-24. OU 8 Geologic Cross-Section Showing DCA Concentrations.
SUBASE Bangor OU8.

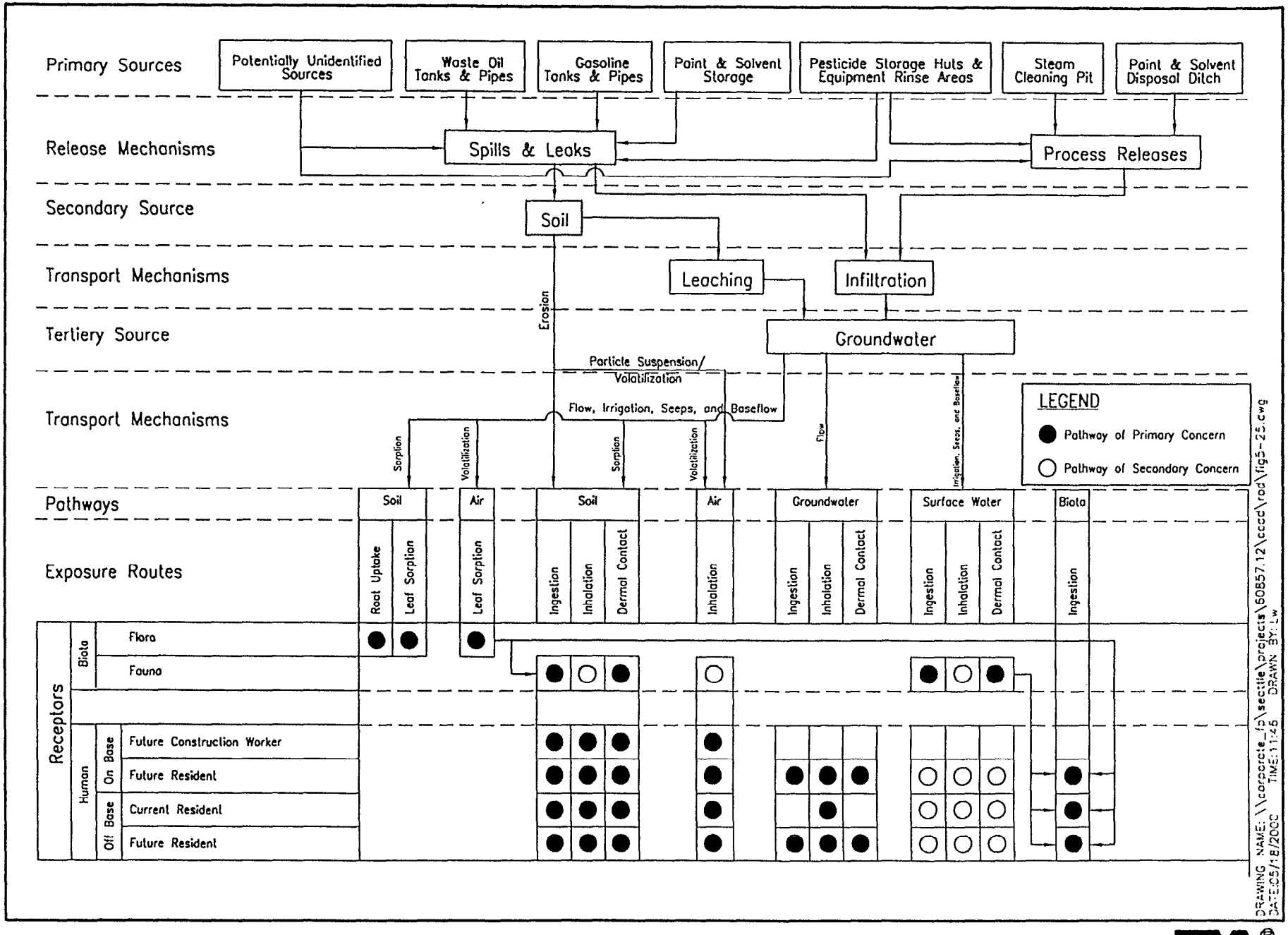
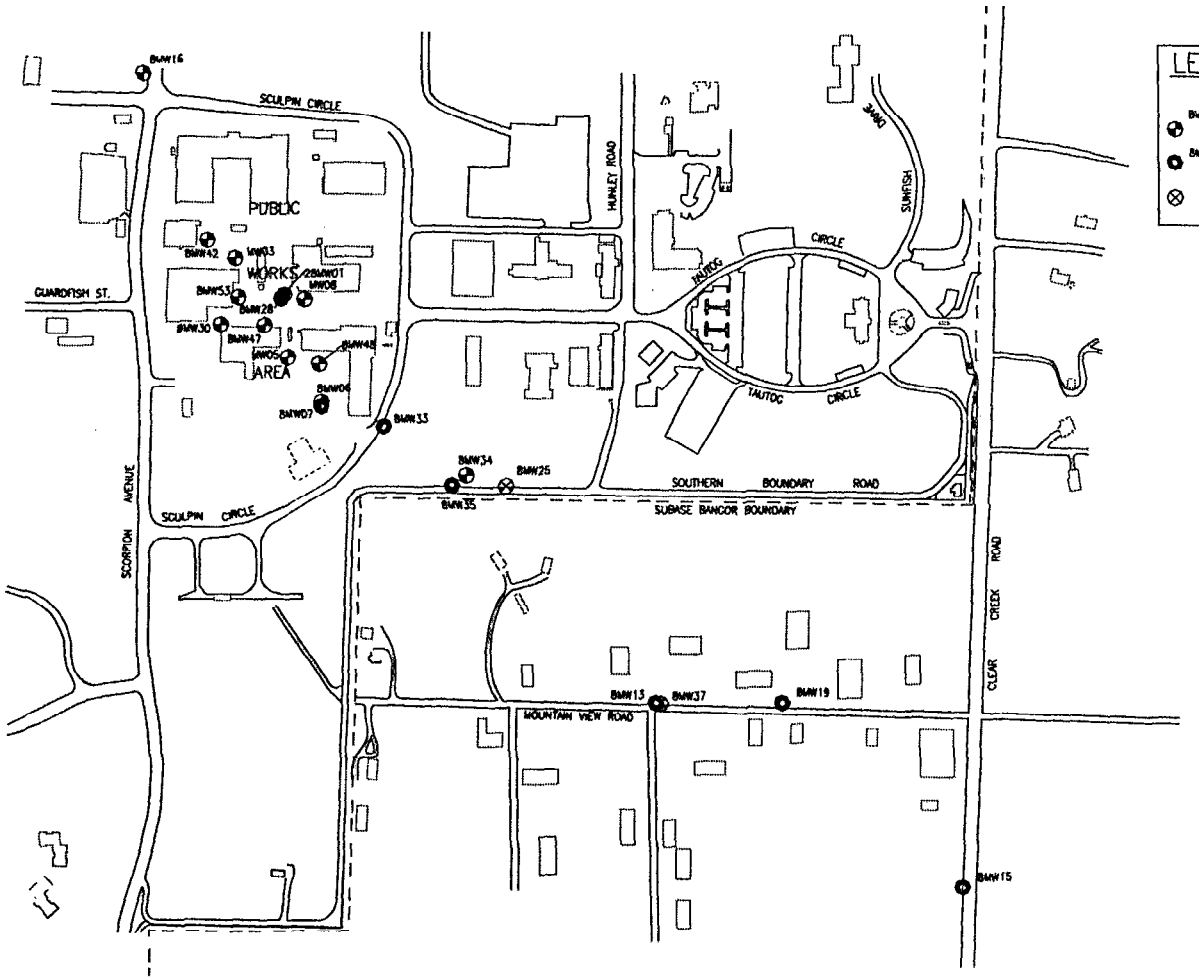


Figure 5-25. Conceptual Site Model for OU 8.
SUBASE Bangor OU 8.



LEGEND

- BMW02 — SHALLOW MONITORING WELL (COMPLETED WITHIN 30' OF WATER TABLE)
- BMW03 — INTERMEDIATE MONITORING WELL (APPROXIMATE COMPLETION DEPTH 220-180' MSL)
- BMW37 — DEEP MONITORING WELL (COMPLETED WITHIN APPROXIMATELY 30' OF LAWTON CLAY SURFACE)

SUBASE Bangor OU 8

Figure 5-26 Natural Attenuation Parameter Sampling Locations

400 200 0 400

GRAPHIC SCALE IN FEET

Figure 5-27. Concentrations of Natural Attenuation Parameters Along Flow Path - Phase II
SUBASE Bangor OU 8, Feasibility Study

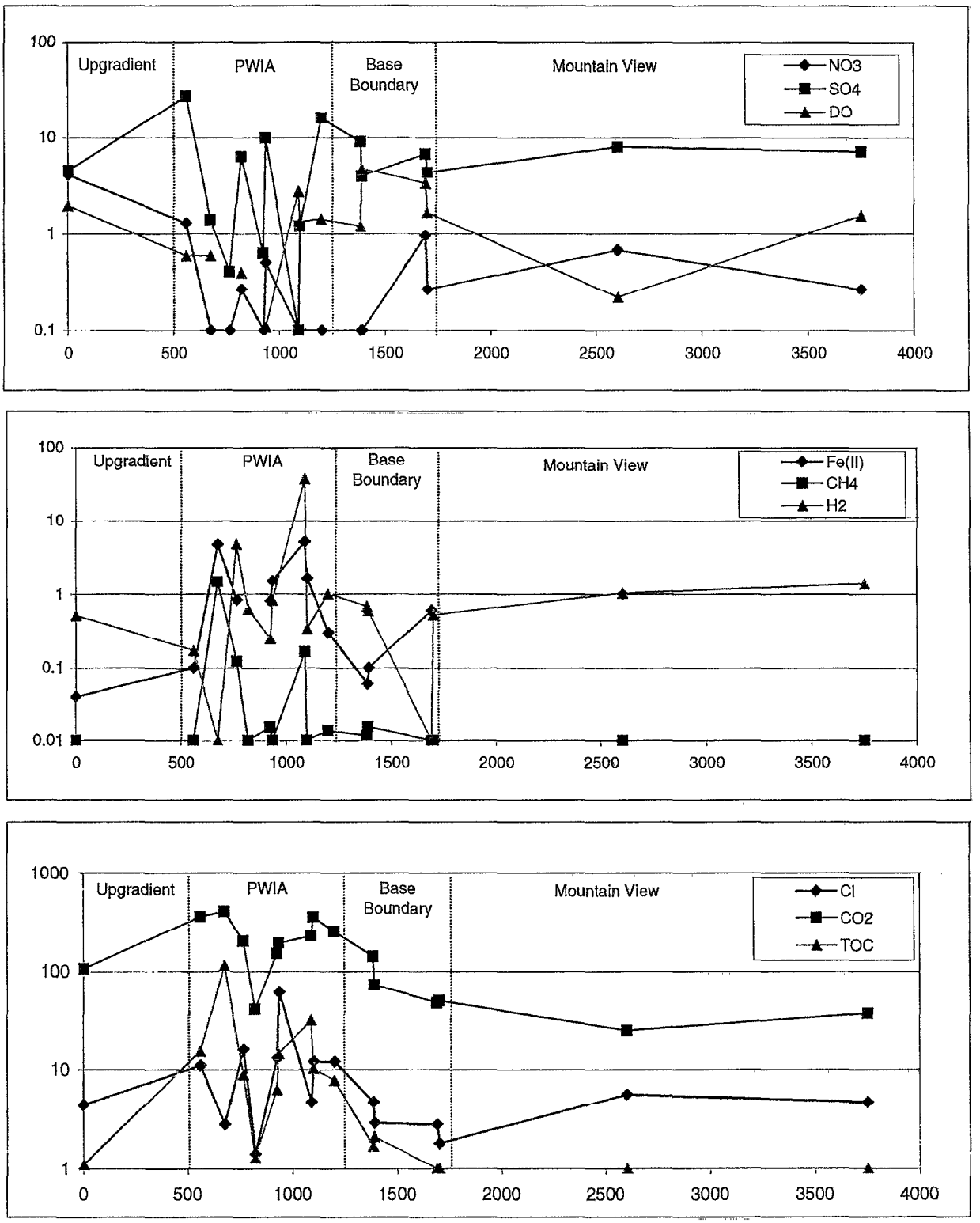
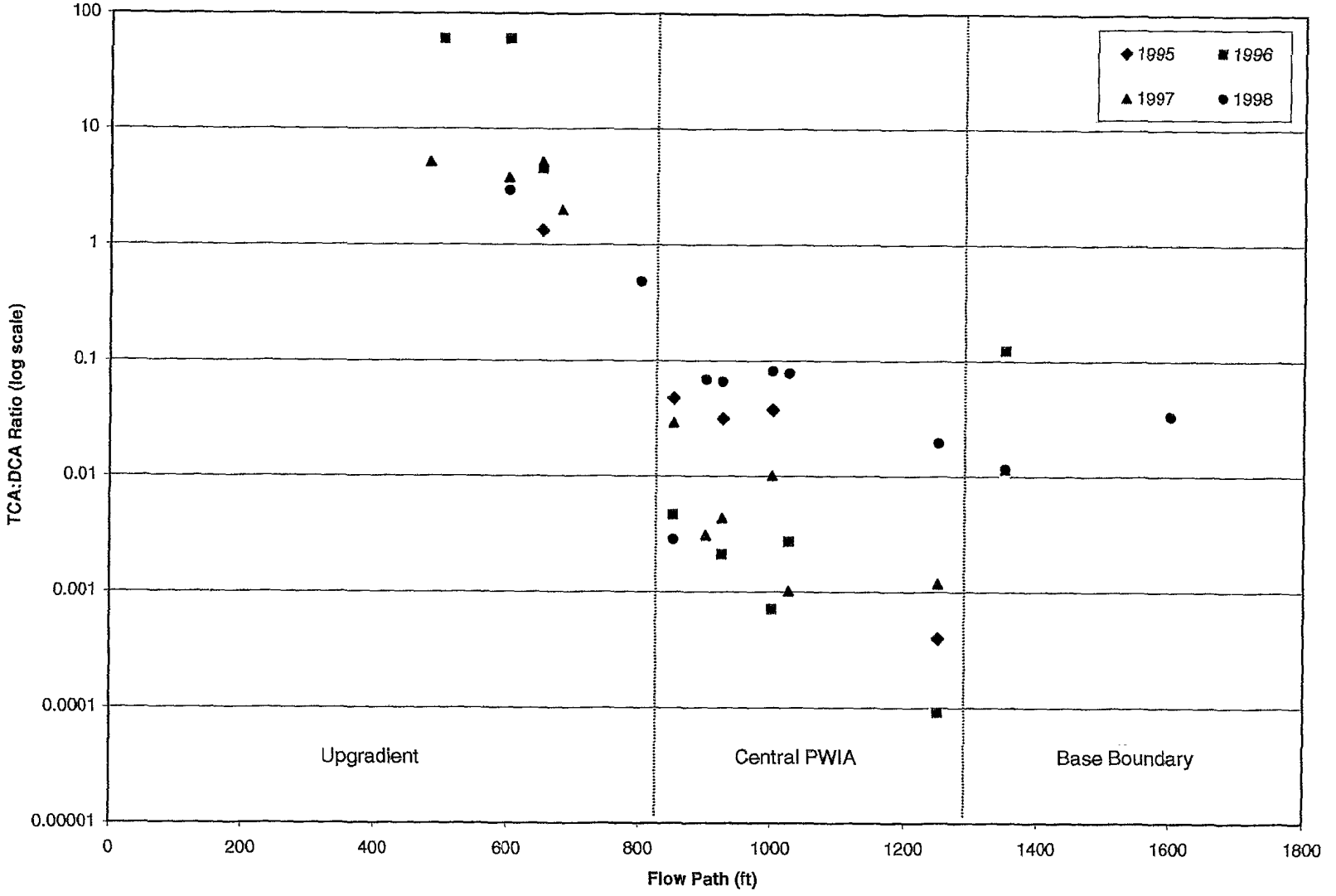


Figure 5-28. TCA:DCA Ratios in Shallow Wells
SUBASE Bangor OU 8, Feasibility Study



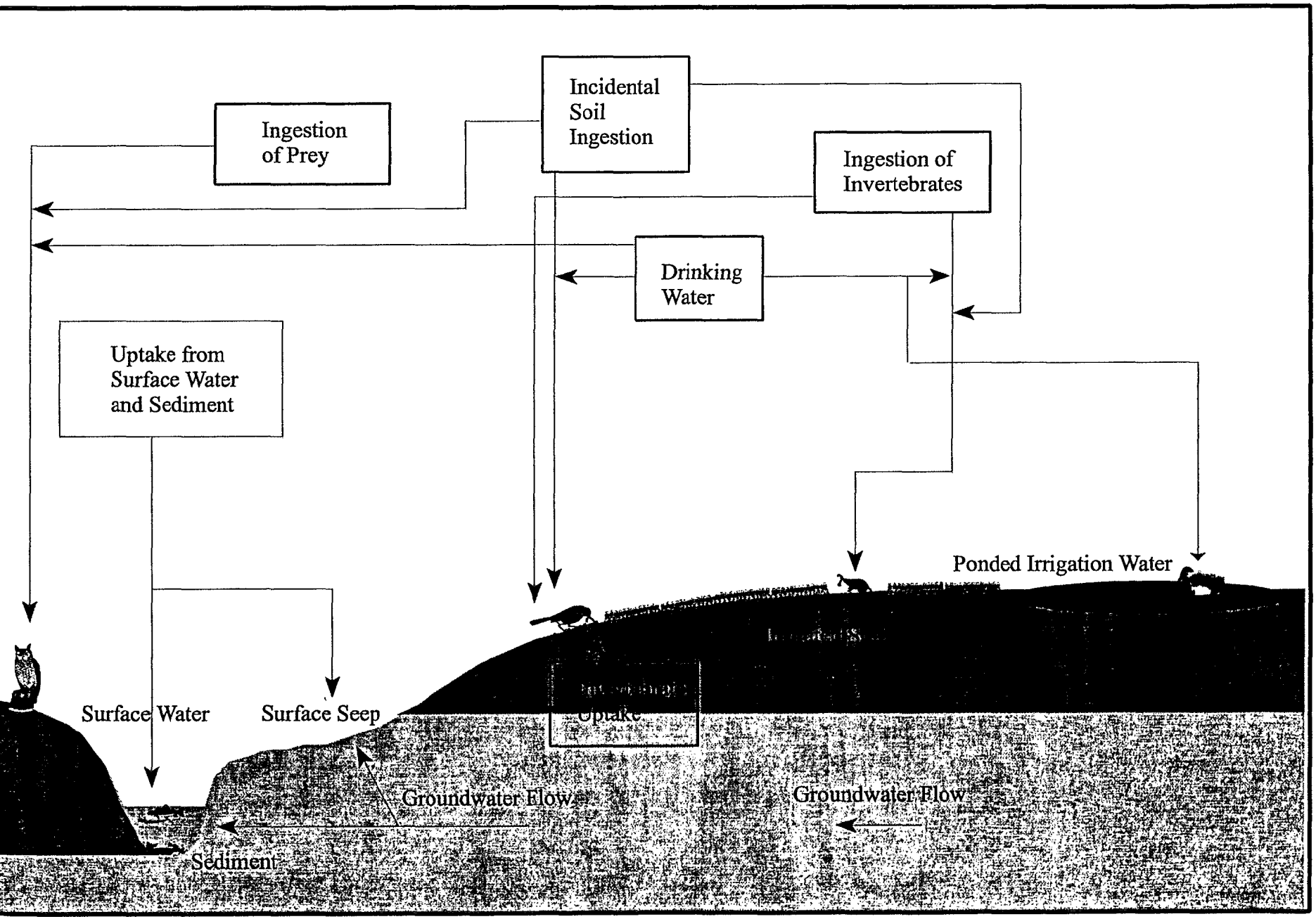


Figure 7-1. Conceptual Ecological Exposure Model for OU 8.
SUBASE Bangor OU 8

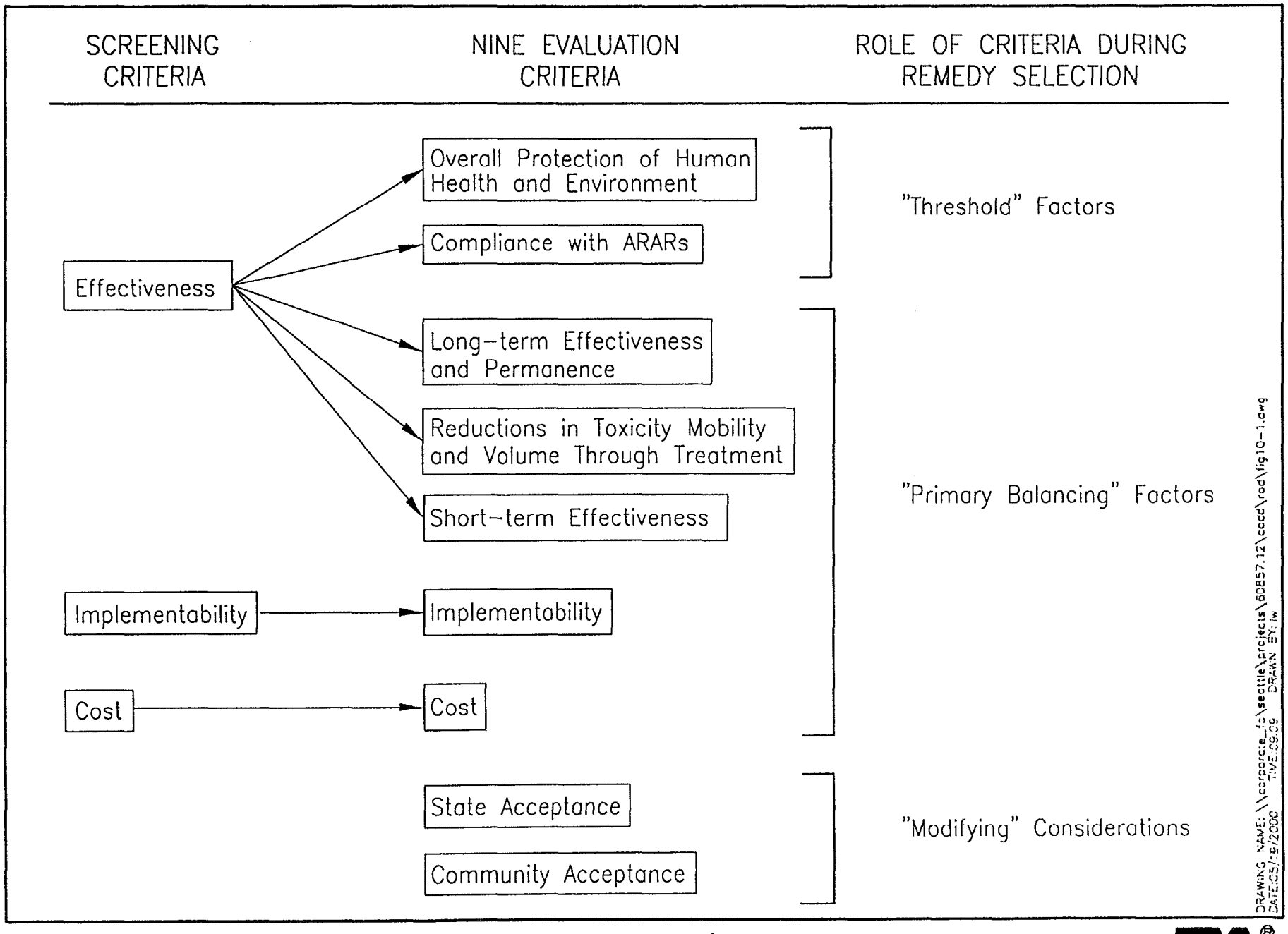


Figure 10-1. Screening Criteria and EPA's Nine Evaluation Criteria.
SUBASE Bangor OU 8.

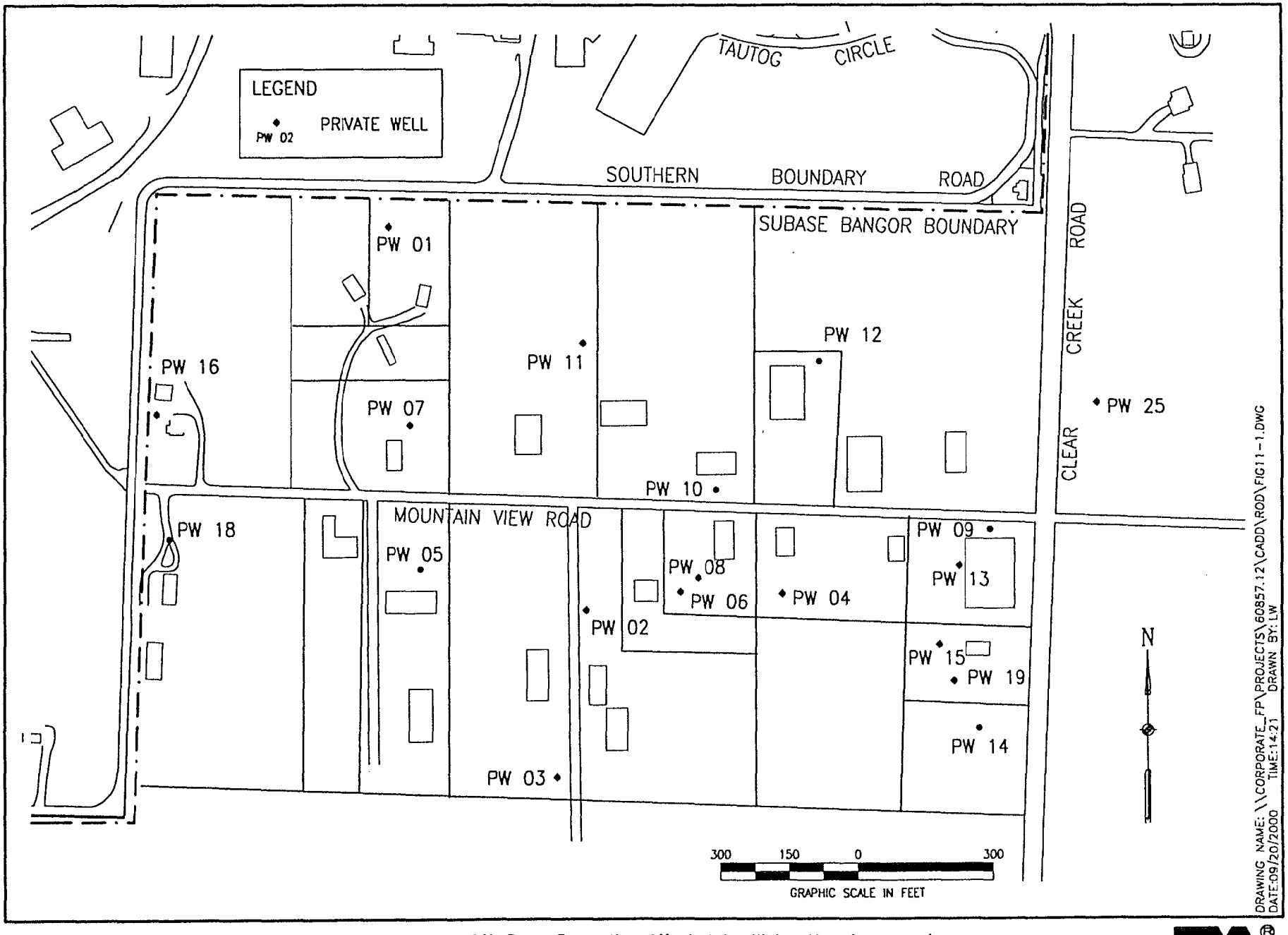


Figure 11-1. Off-Base Properties Affected by Water Use Agreements.

APPENDIX A

Public Announcement of the OU 8 Proposed Plan and Public Comment Period

Appendices

SUBASE Bangor Proposed Plan
Information Session Scheduled
May 16, 2000

The Navy, Environmental Protection Agency (EPA), and Washington State Department of Ecology invite public input and comment on a Proposed Cleanup Plan for Operable Unit (OU) 8, Naval Submarine Base, Bangor. The Plan outlines technologies being considered for cleaning up chemicals found in groundwater at this site so that potential future health risks associated with these chemicals are minimized.

A 30-day public comment period runs May 12 to June 13, 2000.

You are invited to attend a May 16th Information Session and Public Meeting to discuss and comment on the proposals. Written and verbal comments will be accepted from you during the meeting, and at anytime during the 30-day comment period.

Information Session: 6 p.m. to 7 p.m.
Public Meeting: 7 p.m. to 9 p.m.
Tuesday, May 16, 2000
Poulsbo Fire Station
911 N. E. Liberty Rd.
Poulsbo, WA 98370

OU 8 is located in the southeast portion of the base and was investigated due to past practices associated with the Public Works Industrial Area. Petroleum and volatile organic carbons have been found in the groundwater and soil.

The Navy considered seven different cleanup technologies:

- **Land Use Control**—a legal agreement that prohibits contact with, and use of groundwater both on- and off-base, by physical and/or land use restrictions.
- **Long Term Monitoring**—provides information that can be used to measure performance of other technologies.
- **Monitored Natural Attenuation—**removes groundwater contaminants through biological and chemical processes that occur naturally, without human assistance.
- **Soil Vapor Extraction—**pulls vapor from contaminated soil underground and burns it in a treatment unit before releasing it to the air.
- **Reduction/Oxidation (Redox) Manipulation**—aids the biological removal of chemicals by adding oxygen to the groundwater. This "bio-sparging" process (adding air to the groundwater) enhances natural attenuation by increasing microorganism activity.
- **Free Product Recovery**—removes fuel floating on the surface of the groundwater by pumping or bailing it out.
- **Pump and Treat**—minimizes further off-base expansion of contaminated groundwater by bringing up contaminated water from the water table, removing chemicals, and returning the cleaned water back to the water table.

After extensive evaluations and studies on each of the above technologies, the Navy, EPA and Ecology believe the best protection against potential risk to human health and the environment is a combination of three cleanup technologies: **Monitored Natural Attenuation, Free Product Recovery, and Land Use Control.** After all public comment is reviewed, a final cleanup technology selection will be published in a Record of Decision.

(MORE)

Comments should be addressed to:

Mick Butterfield, B451
Environmental Resources Division
1101 Tautog Circle
Silverdale, WA 98315-1087
Phone: 360/396-5100
Fax: 360/396-396-7196
e-mail: mick.butterfield@subase.nsb.navy.mil

A copy of this Proposed Plan, the Remedial Investigation and Feasibility Study report, and other documents containing information directly related to the decision concerning the OU 8 clean up can be found at the following locations:

Central Kitsap Library	**Kitsap PUD**	**SUBASE Bangor Library**
1301 Sylvan Way	**1931 Finn Hill Rd. (Base access required)**	
Bremerton, WA 98310	**Poulsbo, WA 98370**	
360/377-7601	**360/895-5777**	

Information regarding OU 8 can also be obtained by appointment from:

SUBASE Bangor Administrative Record
Engineering Field Activity, Northwest
Naval Facilities Engineering Command
19917 7th Avenue, N.E.
Poulsbo, WA 98370-7570
Librarian: 360/396-0034

APPENDIX B

Exposure Point Concentrations of COPCs
1995/96 Risk Assessment

Table B-1. Selection of Chemicals of Concern from List of Detections in Off-Base Groundwater.

Chemical	Max Conc. mg/L	Screening Concentrations			Max>RBC?	Detection Frequency	Freq.≥5%?	COPC?
		EPA Region 3 RBC mg/L	EPA Region 9 PRG Tap Water mg/L	MTCA Method B mg/L				
Acetone	240	370	61	80	Yes	6/45	Yes	Yes
Benzene	1700	0.36	0.39	1.51	Yes	28/117	Yes	Yes
Bromodichloromethane	1	0.17	0.18	0.706	Yes	5/117	No	No
2-Butanone	11	190	190	480	No	3/42	Yes	No
Carbon tetrachoride	3	0.16	0.17	0.337	Yes	5/117	No	No
Carbon disulfide	0.21	100	2.1	80	No	12/45	Yes	No
Cloroethane	0.4	860	71		No	1/117	No	No
Chloroform	45	0.15	0.16	7.17	Yes	23/117	Yes	Yes
Chloromethane	0.31	1.4	1.5	3.37	No	2/117	No	No
cis-1,2-Dichloroethene	0.02	6.1	6.1	8	No	1/117	No	No
1,1- Dichlorethane	0.5	81	81	80	No	6/117	Yes	No
1,2- Dichloroethane	420	0.12	0.12	0.481	Yes	25/116	Yes	Yes
1,1- Dichloroethane	20	0.044	0.046	0.0729	Yes	11/116	Yes	Yes
1,2 - Dichloropropane	27	0.16	0.16	0.643	Yes	11/117	Yes	Yes
Ethylbenzene	2	130	150	80	No	18/117	Yes	No
Methylene Chloride	0.047	4.1	4.3	5.83	No	6/117	Yes	No
Tetrachlorethene	0.05	1.1	1.1	0.858	No	1/117	No	No
Toluene	19	75	72	160	No	26/117	Yes	No
trans-1,2-Dichloroethene	0.1	12	12	16	No	1/117	No	No
1,1,2-Trichloroethane	57	0.19	0.2	0.768	Yes	11/117	Yes	Yes
1,1,1-Trichloroethane	0.02	79	79	720	No	4/117	No	No
Trichloroethene	0.11	1.6	1.6	3.98	No	1/117	No	No
1,2,4-Trimethylbenzene	0.6	30			No	1/75	No	No
Vinyl chloride	0.5	0.019	0.02	0.023	Yes	1/117	No	No
m-Xylene + p-Xylene	5	1200	140	1600	No	1/75	No	No
o-Xylene	3	140	140	1600	No	1/75	No	No
Xylenes, total	8	1200	140	1600	No	23/42	Yes	No
Semivolatile Organic Compounds								
bis(2-Chloroethyl)ether	8	0.0092	0.0098	0.0398	Yes	1/8	Yes	Yes
bis(2-Ehthylhexl)phthalate	20	4.8	4.8	6.25	Yes	3/8	Yes	Yes
Di-n-butyphthalate	1	370	370	160	No	1/8	Yes	No
Isophorone	1	71	71	92.1	No	2/8	Yes	No
2-Methylphenol	1	180	180	80	No	1/8	Yes	No
Phenol	1	2200	2200	960	No	1/8	Yes	No

Table B-2. Selection of Chemicals of Concern from List of Detected Analytes in Off-Base Surface Soil (i.e., Sediments).

		Screening Concentrations						
Chemical	**Max. Conc mg/kg**	**Residential mg/kg**	**EPA Region 9 PRG Res Soil mg/kg**	**MTCA Method B mg/kg**	**Max. > Screening Concentration?**	**Detection Frequency**	**Frequency ≥ 5%?**	**COPC?**
Volatile Organic Compounds								
Acetone	0.35	780	210	8	No	1/4	Yes	No
Toluene	0.09	1600	79	16	No	2/3	Yes	No
Semivolatile Organic Compounds								
4-Methylphenol	0.99	39	33	0.8	Yes	1/2	Yes	Yes

Table B-3. Selection of Chemicals of Concern from List of Detected Analytes Off-Base Surface Water (i.e., Seeps).

Chemical	Max Conc. mg/L	Screening Concentrations			Max. > Screening Concentration?	Detection Frequency	Frequency ≥5%?	COPC?
		EPA Region 3 RBC ug/L	EPA Region 9 PRG Tap Water mg/L	MTCA Method B mg/L				
Volatile Organic Compounds								
Benzoic acid	9	15000	15000	6400	No	3/3	Yes	No
Toluene	9	75	72	160	No	1/3	Yes	No
Semivolatile Organic Compounds								
bis(2-Ethylhexyl)phthalate	4	4.8	4.8	6.25	No	1/3	Yes	No
Di-n-octylphthalate	10	73	73		No	1/2	Yes	No

Table B-4. Selection of Chemicals of Concern from List of Detected Analytes in On-Base Groundwater

Chemical	Max Conc mg/L	Screening Concentrations			Max. > Screening Concentration?	Detection Frequency	Frequency ≥5%?	COPC?
		EPA Region 3 RBC ug/L	EPA Region 9 PRG Tap Water mg/L	MTCA Method B mg/L				
Acetone	1300	370	61	80	Yes	20/272	Yes	Yes
Benzene	18000	0.36	0.39	1.51	Yes	170/279	Yes	Yes
Benzoic acid	66	15000	15000	6400	No	3/20	Yes	No
Bromodichloromethane	1	0.17	0.18	0.706	Yes	16/299	Yes	Yes
2-Butanone	240	190	190	480	Yes	10/203	No	No
Carbon disulfide	5	100	2.1	80	Yes	44/221	Yes	Yes
Carbon tetrachloride	3.4	0.16	0.17	0.337	Yes	19/280	Yes	Yes
Chloroethane	2	860	71		No	5/280	No	No
Chloroform	3	0.15	0.16	7.17	Yes	62/280	Yes	Yes
Chloromethane	9.9	1.4	1.5	3.37	Yes	6/280	No	No
2-Chlorotoluene	51	12	12	16	Yes	1/77	No	No
cis-1,2-Dichloroethene	4	6.1	6.1	8	No	5/280	No	No
Dibromochloromethane	0.4	0.13	1	0.521	Yes	3/55	No	No
1,3-Dibromoethane (EDB)	300	0.00075	0.00076	0.000515	Yes	27/280	Yes	No
1,1-Dichloroethane	10	81	81	80	No	46/281	Yes	Yes
1,1 Dichlorethene (DCE)	12	0.044	0.046	0.0729	Yes	35/280	Yes	Yes
1,2-Dichloroethane(DCA)	2000	0.12	0.12	0.481	Yes	90/280	Yes	No
1,2-Dichloropropane	9.7	0.16	0.16	0.643	Yes	32/280	Yes	Yes
1,3-Dichlorobenzene	0.06	54	18		No	1/280	No	No
1,4-Dichlorobenzene	1	0.44	0.47	1.82	Yes	13/281	No	No
Ethylbenzene	1900	130	130	80	Yes	153/280	Yes	Yes
2-Hexanone	120	290	16	64	Yes	2/203	No	No
Isopropylbenzene	60	150	1.9	64	Yes	18/77	Yes	Yes
Isopropyltoluene	16	150	1.9	6.4	Yes	3/77	No	No
Methylene Chloride	240	4.1	4.3	5.83	Yes	24/279	Yes	Yes
n-Propylbenzene	150	150	1.9	64	Yes	12/77	Yes	Yes
sec-Butylbenzene	1	6.1			No	2/77	No	No
Styrene	3.5	161	160	1.46	Yes	2/280	No	No
tert-Butylbenzene	49	6.1			Yes	1/77	No	No
Tetrachloroethene (PCE)	1	1.1	1.1	0.858	Yes	12/282	No	No
1,1,2,2-Tetrachloroethane	0.3	0.052	0.055	0.219	Yes	2/279	No	No
Toluene	27000	75	72	160	Yes	143/280	Yes	Yes
trans-1,2-Dichloreoethene	0.08	12	12	16	No	1/280	No	No
Trichloroethene	7	1.6	1.6	3.98	Yes	15/280	Yes	Yes
1,1,1-Trichloroethane	45	79	79	720	No	60/281	Yes	No
1,1,2-Trichloroethane	27	0.19	0.2	0.768	Yes	30/280	Yes	Yes
1,2,4-Trimethylbenzene	2800	30			Yes	23/77	Yes	Yes
1,3,5-Trimethylbenzene	620	30			Yes	18/77	Yes	Yes

Table B-4. Selection of Chemicals of Concern from List of Detected Analytes in On-Base Groundwater.

Chemical	Max Conc. µg/L	Screening Concentrations			Max. > Screening Concentration?	Detection Frequency	Frequency ≥5%	COPC?
		EPA Region 3 RBC ug/L	EPA Region 9 PRG Tap Water µg/L	MTCA Method B µg/L				
Vinyl chloride	0.4	0.019	0.02	0.023	Yes	2/280	No	No
m-Xylene + p-Xylene	7700	1200	140	1600	Yes	24/77	Yes	Yes
o-Xylene	3600	140	140	1600	Yes	24/77	Yes	Yes
Xylenes, total	12000	1200	140	1600	Yes	150/203	Yes	Yes
Semivolatile Organic Compounds								
Acenaphthene	18	220	37	96	No	2/93	No	No
bis(2-Chloroethyl)ether	13	0.0092	0.0098	0.0398	Yes	11/93	Yes	Yes
bis(2-Chloroisopropyl)ether	5	0.26	0.27	32	Yes	8/93	Yes	Yes
bis(2-Ethylhexyl)phthalate	1000	4.8	4.8	6.25	Yes	45/93	Yes	Yes
Bromacil	69				No	39/90	Yes	Yes
4-Chloro-3-methylphenol	6	18	18	8	No	1/93	No	No
2-Chlorophenol	4	18	3.8	8	Yes	1/93	No	No
Di-n-butylphthalate	1	370	370	160	No	8/93	Yes	No
Diethylphthalate	1	2900	2900	1280	No	1/93	No	No
2,4- Dimethylphenol	10	73	73	32	No	4/92	No	No
Dimethylphthalate	1	37000	37000	1600	No	1/93	No	No
Fluorene	41	150	24	64	Yes	1/93	No	No
Isophorone	1	71	71	92.1	No	4/93	No	No
4- Methyl-1-2-pentanone (MIBK)	98	290	16	64	Yes	2/203	No	No
2- Methylnaphthalene	370	150	24	32	Yes	24/94	Yes	Yes
2- Methylphenol	81	180	180	80	Yes	10/93	Yes	Yes
4- Methylphenol	73	18	18	8	Yes	7/93	Yes	Yes
Naphthalene	690	150	24	32	Yes	39/151	Yes	Yes
Phenanthrene	42	110	18	48	Yes	1/93	No	No
Phenol	49	2200	2200	960	No	17/94	Yes	No
Pyrene	3	110	18	48	No	1/93	No	No

Table B-5. Selection of Chemicals of Concern from List of Detected Analytes in On-Base Subsurface Soil.

Chemical	Max Conc.	Screening Concentrations			Max > Screening Concentration?	Detection Frequency	Frequency ≥5%	COPC?
		Residential mg/kg	EPA Region 9 PRG Res Soil mg/kg	Method B mg/kg				
Acetone	0.68	780	210	8	No	13/25	Yes	No
Benzene	0.46	22	0.63	0.151	Yes	2/25	Yes	Yes
Benzoic acid	0.66	31000	100000	640	No	1/4	Yes	No
2-Butanone (MEK)	0.055	4700	710	48	No	11/21	Yes	No
Carbon disulfide	0.002	780	0.75	8	No	1/24	No	No
Chloroform	0.001	100	0.25	0.717	No	1/25	No	No
Ethylbenzene	21	780	230	8	Yes	2/25	Yes	yes
Isopropyltoluene	0.7	310	1.9	6.4	No	2/4	Yes	No
4-Methyl-2-pentanone (MIBK)	0.047	630	77	6.4	No	4/21	Yes	No
Methylene Chloride	0.004	85	7.8	0.583	No	4/24	Yes	No
Tetrachloroethene	0.003	12	5.4	0.0858	No	1/25	No	No
Toluene	36	1600	79	16	Yes	6/25	Yes	Yes
Xylenes, total	150	16000	320	160	No	7/21	Yes	No
Semivolatile Organic Compounds								
Anthracene	0.62	2300	5.7	48	No	1/20	Yes	No
Benz(a)anthracene	0.23	0.88	0.61	0.0012	Yes	2/20	Yes	Yes
Benzo(a)pyrene	0.12	0.088	0.061	0.0012	Yes	2/20	Yes	Yes
Benzo(b)fluoranthene	0.15	0.88	0.61	0.0012	Yes	1/20	Yes	Yes
Benzo(k)fluoranthene	0.048	8.8	0.61	0.0012	Yes	1/20	Yes	Yes
Bis(2-Ethylhexyl)phthalate	2.6	46	32	0.625	Yes	7/20	Yes	Yes
Chrysene	0.29	88	6.1	0.0012	Yes	4/20	Yes	Yes
Dibenzofuran	0.38	31	140	N/A	No	1/20	No	No
Fluranthene	0.93	310	260	6.4	No	3/20	Yes	No
Fluorene	1.6	310	90	6.4	No	2/20	Yes	No
2-Methylnapthalene	15	310	240	3.2	Yes	4/20	Yes	Yes
Phenanthrene	2.5	230	100	4.8	No	4/24	Yes	No
Phenol	0.33	4700	3900	96	No	2/20	Yes	No
Pyrene	0.75	230	100	4.8	No	5/20	Yes	No

Table B 6. Summary of Chemicals of Potential Concern of All Exposure Media

Chemical of Concern	Off-Base						On-Base				
	Surface Soil	Ground-water	Seeps	Air	Plant Tissue	Animal Tissue	Subsurface Soil	Ground-water	Air	Plant Tissue	Animal Tissue
Volatile Organic Compounds											
Acetone	T	T		T	T	T		T	T	T	T
Benzene	T	T		T	T	T	T	T	T	T	T
Bromodichloromethane								T	T	T	T
Carbon disulfide								T	T	T	T
Carbon tetrachloride								T	T	T	T
Chloroform	T	T		T	T	T		T	T	T	T
1,2-Dibromoethane (EDB)								T	T	T	T
1,2-Dichloroethane (DCA)		T		T	T	T		T	T	T	T
1,1-Dichloroethene (DCE)	T	T		T	T	T		T	T	T	T
1,2-Dichloropropane	T	T		T	T	T		T	T	T	T
Ethylbenzene							T	T	T	T	T
Isopropylbenzene								T	T	T	T
Methylene chloride								T	T	T	T
n-Propylbenzene								T	T	T	T
Toluene							T	T	T	T	T
1,1,2-Trichloroethane	T	T		T	T	T		T	T	T	T
Trichloroethene								T	T	T	T
1,2,4-Trimethylbenzene								T	T	T	T
1,3,5-Trimethylbenzene								T	T	T	T
m-Xylene + p-Xylene								T	T	T	T
o-Xylene								T	T	T	T
Xylenes, total								T	T	T	T
Semivolatile Organic Compound											
Benz(a)anthracene							T		T		
Benzo(a)pyrene							T		T		
Benzo(b)fluoranthene							T		T		
Benzo(k)fluoranthene							T		T		
bis(2-chloroethyl)ether	T	T		T	T	T	T	T	T	T	T
bis(2-Chloroisopropyl)ether								T	T	T	T
bis(2-Ethylhexyl)phthalate	T	T		T	T	T	T	T	T	T	T
Bromacil								T	T	T	T
Chrysene							T		T		

Table B-6. Summary of Chemicals of Potential Concern in All Exposure Media.

Chemical of Concern	Off-Base						On-Base				
	Surface Soil	Ground-water	Seeps	Air	Plant Tissue	Animal Tissue	Subsurface Soil	Ground-water	Air	Plant Tissue	Animal Tissue
2-Methylnapthalene							T	T	T	T	T
4-Methylphenol	T			T	T	T		T	T	T	T
2-Methylphenol								T	T	T	T
Naphthalene								T	T	T	T

Note: COPC list includes both measured and modeled COPC for each environmental medium.

Table B-7. Summary Statistic for Chemicals of Potential Concern in Off-Base Groundwater.

Chemical of Concern	Frequency Detected	Range of Detection (Fg/kg)	Arithmetic Mean (Fg/kg)	95 UCLM (Fg/kg)
Volatile Organic Compound				
Acetone	6/45	2.5-240	9.16	18.05
Benzene	28/117	0.03-1700	33.68	62.62
Chloroform	23/117	0.005-45	1.92	3.12
1,2-Dichloroethane (DCA)	25/116	0.05-420	19.35	31.15
1,1-Dichloroethene (DCE)	11/116	0.1-20	1.03	1.55
1,2-Dichloropropane	11/117	0.05-27	1.46	2.17
1,1,2-Trichloroethane	11/117	0.05-57	2.73	4.20
Semivolatile Organic Compounds				
Bis(2-chloroethyl)ether	1/8	2.5-8	3.19	4.50
Bis(2-ethylhexyl)phthalate	3/8	1-28	8.69	70.73*

*95UCLM value exceeds highest measured value

Table B-8. Summary Statistics for Chemicals of Potential Concern in Off-Base Surface Soils (i.e.,Sediments).

Chemical of Concern	Frequency Detected	Range of Detection (Fg/kg)	Arithmetic Mean (Fg/kg)	95 UCLM (Fg/kg)
Semivolatile Organic Compound				
4-Methylphenol	1/2	190-990	95	3115*

*95UCLM exceeds highest measured value.

Table B-9. Summary Statistics for Chemicals of Concern in On-Base Groundwater.

Chemical of Concern	Frequency Detected	Range of Detection (Fg/kg)	Arithmetic Mean (Fg/kg)	95 UCLM (Fg/kg)
Volatile Organic Compound				
Acetone	20/272	2-1300	49.13	64.95
Benzene	170/279	0.02-18000	528.02	2016.19
Bromodichloromethane	16/229	0.05-250	8.37	11.23
Carbon Disulfide	44/221	0.01-250	11.24	14.75
Carbon Tetrachloride	19/280	0.08-250	7.96	10.62
Chloroform	62/280	0.02-250	26.84	10.29
1,2-Dibromoethane (EDB)	27/280	0.03-300	8.69	12.02
1,2-Dichlorethane (DCA)	90/280	0.05-2000	103.25	386.17
1,1-Dichloroethene (DCE)	35/280	0.02-250	7.95	10.60
1,2-Dichloropropane	32/280	0.05-250	7.86	10.51
Ethylbenzene	153/280	0.02-1900	94.36	194.26
Isopropylbenzene	18/77	0.1-60	5.06	7.60
Methylene Chloride	24/279	0.02-240	10.16	13.50
n-Propylbenzene	12/77	0.1-150	7.53	12.16
Toluene	143/280	0.005-27000	671.50	10661.34
1,1,2-Trichloroethane	30/280	0.05-250	8.53	11.19
Trichloroethene	15/280	0.03-250	7.80	10.46
1,2,4-Trimethylbenzene	23/77	0.1-2800	155.31	634.95
1,3,5-Trimethylbenzene	18/77	0.1-620	43.34	69.79
m-Xylene + p-Xylene	24/77	0.15-7700	390.52	2122.21
o-Xylene	24/77	0.1-3600	201.75	843.09
Xylenes, total	150/203	0.005-12000	400.76	3320.00
Semivolatile Organic Compounds				
bis(2-Chloroisopropyl)ether	8/93	1-25	3.30	4.02
bis(2-ethylhexyl)phthalate	45/93	0.05-1000	22.29	40.93
bis(2-chloroethyl)ether	11/93	1-25	3.55	4.30
Bromacil	39/90	1-69	15.92	22.48
2-Methylnaphthalene	24/94	0.5-370	16.82	25.88
4-Methylphenol	7/93	1.5-73	3.98	5.41
2-Methylphenol	10/93	1-81	4.86	6.69
Naphthalene	39/151	0.5-690	38.90	55.28

Table B-10. Summary Statistics for Chemicals of Potential Concern in On-Base Subsurface Soils.

Chemical of Concern	Frequency Detected	Range of Detection (Fg/kg)	Arithmetic Mean (Fg/kg)	95 UCLM (Fg/kg)
Volatile Organic Compound				
Benzene	2/25	0.3-650	30.73	74.92
Ethylbenzene	2/25	0.45-650	31.94	75.34
Toluene	6/25	0.35-650	30.02	74.26
Semivolatile Organic Compounds				
Benz(a)anthracene	2/20	20.5-1800	298.78	769.87
Benzo(a)pyrene	2/20	21.5-1800	330.93	1086.96
Benzo(b)fluoranthene	1/20	18.5-1800	338.80	1050.21
Benzo(k)fluoranthene	1/20	14-1800	337.80	1285.63
bis(2-ethylhexyl)phthalate	7/20	5.5-1600	308.5	1288.00
Chrysene	4/20	23-1800	301.68	712.23
2-Methylnaphthalene	4/20	20-6400	637.78	1734.64

APPENDIX C

1998/99 Risk Assessment

Table C-1. Selection of Chemicals of Concern from List of Detections Off-Base Groundwater.

Chemical	Max Conc. ug/L	Screening Concentrations			Max > RCB?	Detection Frequency	Freq. > 5%	COPC?
		EPA Region 3 RBC ug/L	EPA Region 9 PRG Tap Water ug/L	MTCA Method B ug/L				
Volatile Organic Compounds								
Acetone	1.1	379	61	80	No	3 / 36	Yes	No
Benzene	76	0.36	0.39	1.51	Yes	23 / 36	Yes	Yes
Carbon tetrachloride	1.8	0.16	0.17	0.337	Yes	32 / 36	Yes	Yes
Chloroethane	0.45	860	71	--	No	3 / 36	Yes	No
Chloroform	2.3	0.15	0.16	7.17	Yes	28 / 36	Yes	Yes
Chloromethane	10	1.4	1.5	3.37	Yes	32 / 36	Yes	Yes
cis-1,2,-Dichloroethene	0.28	6.1	6.1	8	No	2 / 36	Yes	No
1,1-Dichloroethane	2.8	81	81	80	No	9 / 36	Yes	No
1,2,-Dichloroethane	270	0.12	0.12	0.481	Yes	16 / 36	Yes	Yes
1,1-Dichloroethane	16	0.046	0.046	0.0729	Yes	27 / 36	Yes	Yes
1,2-Dichloropropane	12	0.16	0.16	0.643	Yes	25 / 36	Yes	Yes
Methylene Chloride	9.8	4.1	4.3	5.83	Yes	22 / 36	Yes	Yes
Toluene	0.38	75	72	160	No	7 / 36	Yes	No
trans-1,2-Dichloroethene	0.13	12	12	16	No	2 / 36	Yes	No
1,1,2- Trichloroethane	34	0.19	0.2	0.768	Yes	23 / 36	Yes	Yes
1,1,1-Trichloroethane	5.5	79	79	720	No	9 / 36	Yes	No
Trichloroethene	2.5	1.6	1.6	3.98	Yes	27 / 36	Yes	Yes
Vinyl chloride	0.25	0.019	0.02	0.023	Yes	31 / 36	Yes	Yes
m-Xylene + p-Xylene	0.26	1200	140	1600	No	3 / 36	Yes	No
Xylenes, total	0.26	1200	140	1600	No	3 / 36	Yes	No
Semivolatile Organic Compounds								
bis(2-Chloroethyl)ether	8	0.0092	0.0098	0.0398	Yes	1 / 4	Yes	Yes
bis(2-Ethylhexyl)phthalate	1	4.8	4.8	6.25	No	2 / 4	Yes	No

Notes: -- Screening concentration for chemical is not listed.

Table C-2. Summary of Chemical of Potential Concern in Off-Base Groundwater.

Chemical of Concern	Frequency Detected	Range of Detection (ug/L)	Arithmetic Mean (ug/L)	95 UCML (ug/L)
Volatile Organic Compounds				
Benzene	23 / 36	0.16 - 76	3.8	*3.0*
Carbon tetrachloride	32 /36	0.12 - 1.8	0.5	*0.6*
Chloroform	28 /36	0.12 - 2.3	0.5	*0.6*
Chloromethane	32 / 36	0.44 - 10	1.0	*1.0*
1,2-Dichloroethane	16 / 36	0.17 - 270	21.5	*72.6*
1,1-Dichloroethene	27 / 36	0.39 - 16	1.3	*1.2*
1,2-Dichloropropane	25 / 36	0.13 - 12	1.4	*1.6*
Methylene chloride	22 / 36	0.10 - 9.8	1.1	*1.7*
1,1,2-Trichloroethane	23 / 36	0.24 - 34	3.3	*3.6*
Trichloroethene	27 / 36	0.18 - 2.5	0.5	*0.6*
Vinyl chloride	31 / 36	0.11 - 0.25	0.5	*0.5*
Semivolatile Organic Compounds				
bis(2-Chloroethyl)ether	1 / 4	8 - 8	8	*8*

Table C-3. Summary Statistics for Chemicals of Potential Concern in Off-Base Groundwater.

Chemical	Total Sample	Min (ug/L)	Max (ug/L)	Mean of Distribution (ug/L)	Distribution	Standard Deviation	95UCLM (ug/L)	RME (95UCLM) (ug/L)	RME (Max)	AVG (ug/L)
Volatile Organic Compounds										
Benzene	36	0.16	76	1.75	*L*	13.3	3.0	3.0	76	1.7
Carbon tetrachloride	36	0.12	1.8	0.55	*L*	0.2	0.6	0.6	1.8	0.5
Chloroform	36	0.12	2.3	0.50	*L*	0.3	0.6	0.6	2.3	0.5
Chloromethane	36	0.44	10	0.76	*L*	2.2	1.0	1.0	10	0.8
1,2-Dichloroethane	36	0.17	270	19.35	*L*	52.8	72.6	72.6	270	19.4
1,1-Dichloroethene	36	0.39	16	0.90	*L*	2.9	1.2	1.2	16	0/9
1,2-Dichloropropane	36	0.13	12	1.11	*L*	2.7	1.6	1.6	12	1.1
Methylene chloride	36	0.1	9.8	1.15	*L*	1.6	1.7	1.7	9.8	1.1
1,1,2-Trichloroethene	36	0.24	34	2.02	*L*	8.0	3.6	3.6	34	2.0
Trichloroethene	36	0.18	2.5	0.51	*L*	0.4	0.6	0.6	2.5	0.5
Vinyl chloride	36	0.11	0.25	0.47	*L*	0.1	0.5	0.5	0.3	0.5
Semivolatile Organic Compounds										
bis(2-Chloroethyl)ether	4	8	8	8	--	0	8	8	8	8

APPENDIX D

Derivation of Cleanup Levels for Chemicals of Concern in Groundwater

Table D-1. Derivation of Cleanup Levels for Chemicals of Concern in Groundwater.

Media: Groundwater
Attainment Area (Initial Cleanup Goal): Off-base Shallow Aquifer
Attainment Area (Groundwater Restoration Goal): Site-Wide Groundwater
Available Use: Residential
Controls to Ensure Restricted Use (if applicable): Public water supply has been provided to impacted property owners.

		Chemical-Specific ARARs for COCs (Cleanup Levels are shown Bold & Shaded)			
Chemical of Concern[1]	CAS Number	MTCA Method B[2] (ug/L)	MCL[3] (ug/L)	MCL meets MTCA Risk Standard?[4]	Practical Quantitation Limit[5] (ug/L)
Benzene	71-43-2	1.51	**5**	Yes	5
1,2-Dibromoethane (EDB)	106-93-4	**0.000515**	0.05	No	5
1,2-Dichloroethane (DCA)	107-06-2	0.481	**5**	Yes	5
1,1-Dichloroethene (DCE)	75-35-4	**0.0729**	7	No	5
Toluene	108-88-3	1600	**1000**	Yes	5

CAS - Chemical Abstract Service

1 - Chemical of Concerns were determined using the maximum detected concentrations during the 1999 groundwater sampling events.

2 - State of Washington Model Toxics Control Act (MTCA) Cleanup Regulation (WAC 173-340-720 [3])

3 - Maximum Contaminant Levels (MCLs) under promulgation of the Safe Drinking Water Act (SDWA)

4 - Per MTCA Cleanup Levels and Risk Calculation (CLARC II) February 1996 "Notes on MCL Table," MCLs are only usable as a cleanup standard if when used in the MTCA Method B equations, they result in risks that meet the MTCA standards of 1 x 10-5 excess cancer risk and hazard quotient (HQ) of 1.0.

5 - Ecology Implementation Memo #3 of November 24, 1993.